




# Basic Building Vocabulary

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## Center of gravity

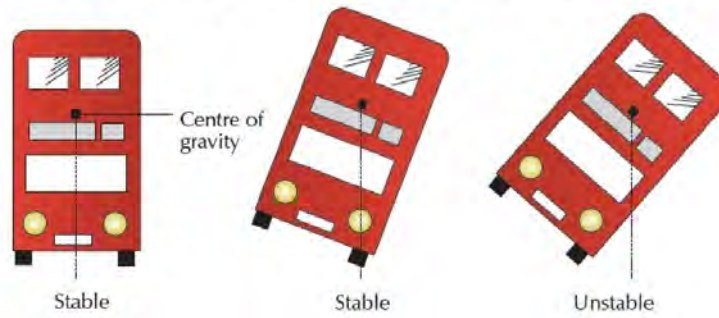
- ▶ a point from which the weight of a body or system may be considered to act.
- ▶ In uniform gravity it is the same as the center of mass.



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# Stability

- An object will topple over if its centre of gravity passes outside its base.



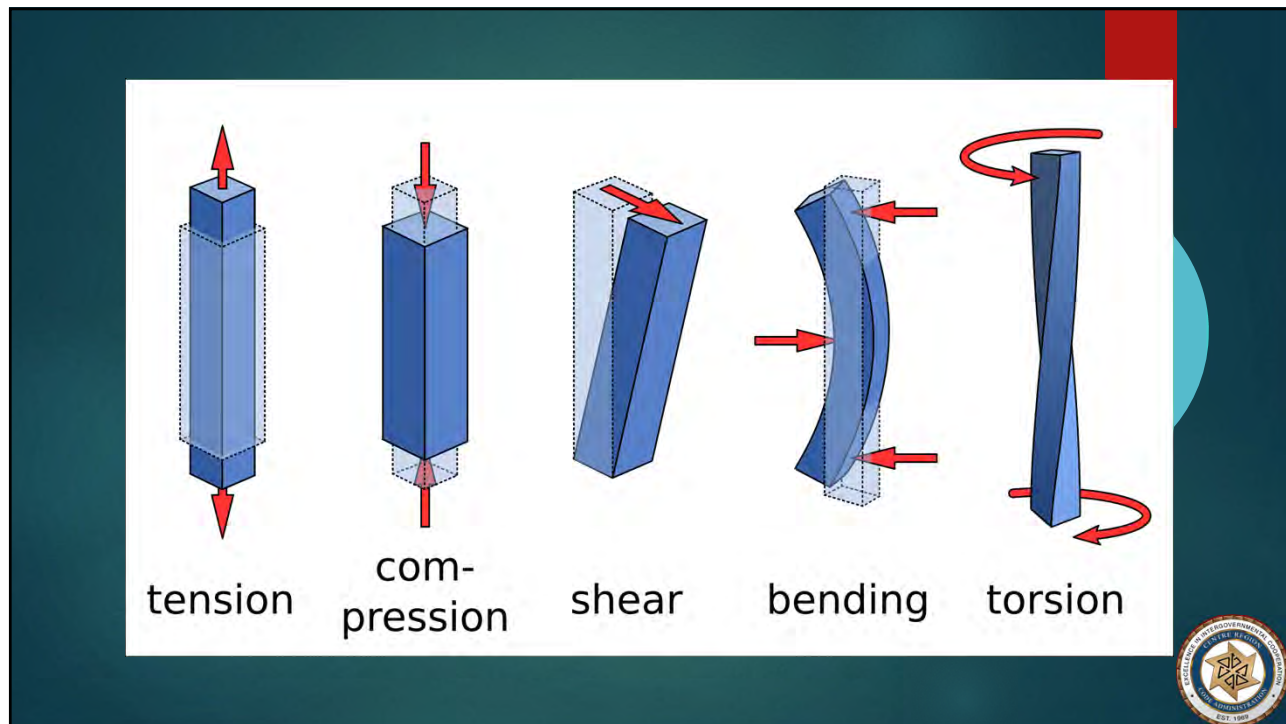
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# Force

Force is any action that tends to maintain or alter the motion of a body or to distort it.



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## Stress

- ▶ The term stress is used to express the loading in terms of force applied to a certain cross-sectional area of an object. From the perspective of loading, stress is the applied force or system of forces that tends to deform a body.
- ▶ Stress is the internal distribution of forces within a body that balance and react to the loads applied to it. The stress distribution may or may not be uniform, depending on the nature of the loading condition.
- ▶ Expressed in units of force per area.

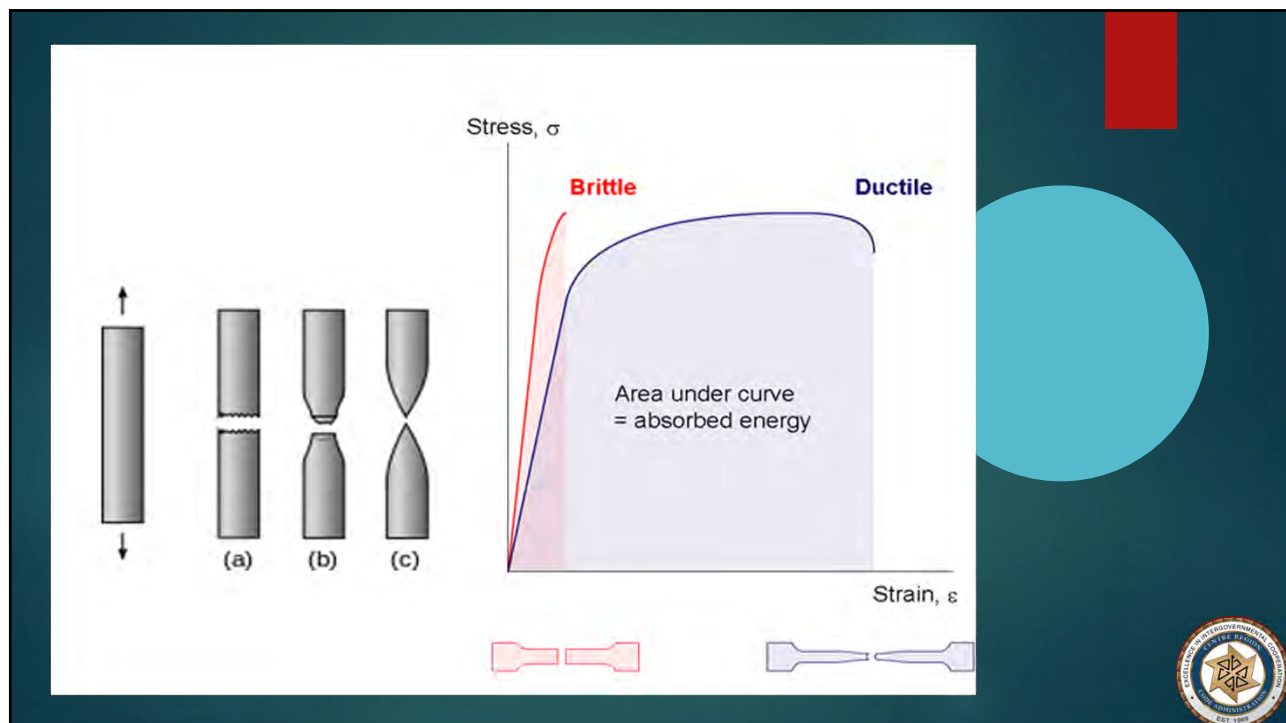
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# Strain

- ▶ Strain is the response of a system to an applied stress
- ▶ Engineering strain is defined as the amount of deformation in the direction of the applied force divided by the initial length of the material. This results in a unitless number, although it is often left in the unsimplified form, such as inches per inch or meters per meter.
- ▶ the strain distribution may or may not be uniform in a complex structural element, depending on the nature of the loading condition.



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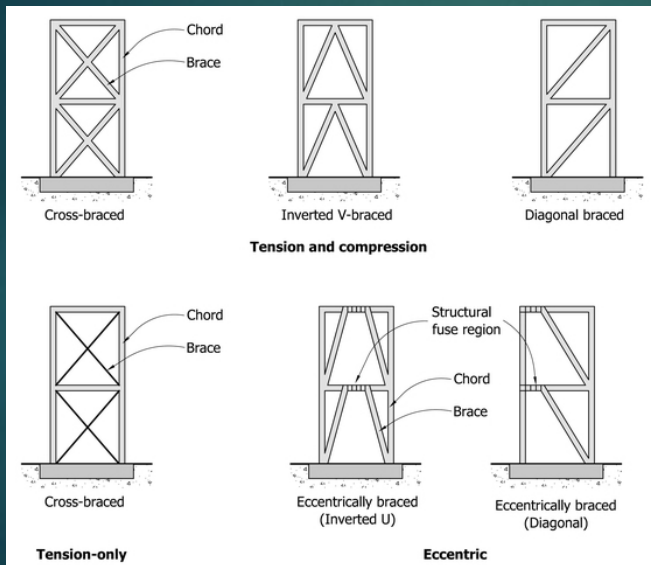
# Redundancy

- ▶ The inclusion of extra components which are not strictly necessary to functioning, in case of failure in other components.
- ▶ Adds cost



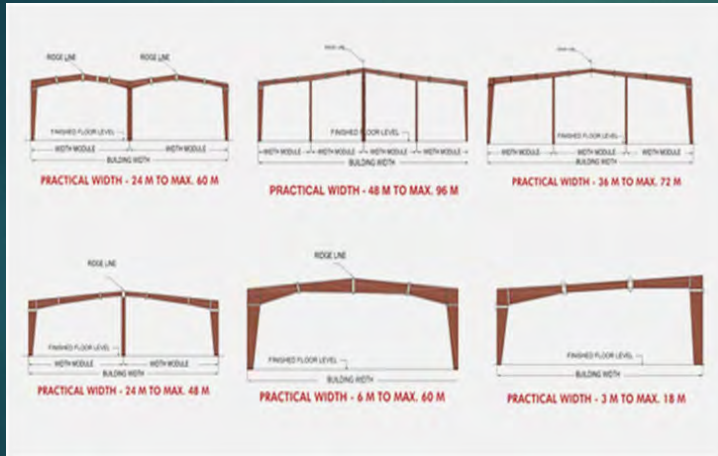
9

# Braced frames



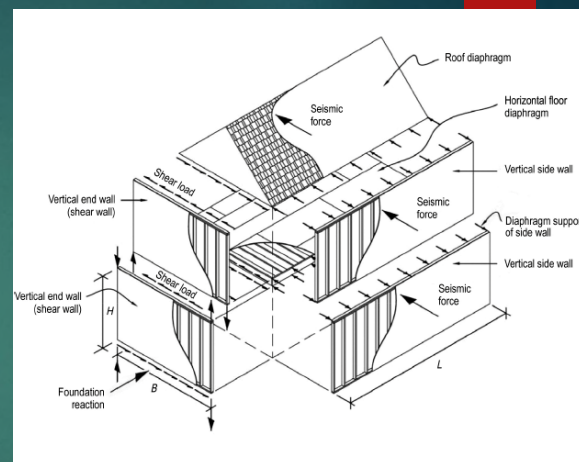
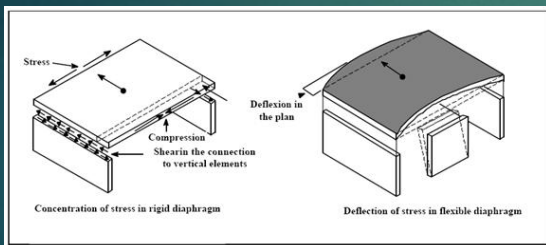
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# Rigid frames



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# Diaphragms



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# Wood

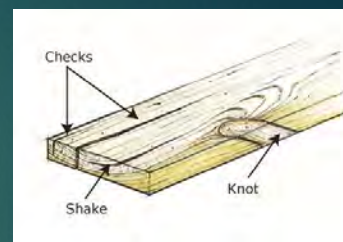
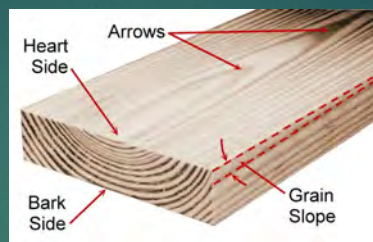
- ▶ Natural Material
- ▶ Species
- ▶ Hardwood
- ▶ Softwood



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# Strength Reducing Characteristics

- ▶ Knots
- ▶ Checks
- ▶ Splits
- ▶ Slope of grain
- ▶ Annular growth ring orientation
- ▶ Pitch pockets
- ▶ Decay
- ▶ Insect damage



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# Solid-Sawn

- ▶ Nominal vs. Actual
- ▶ Boards
- ▶ Dimension Lumber
- ▶ Timbers

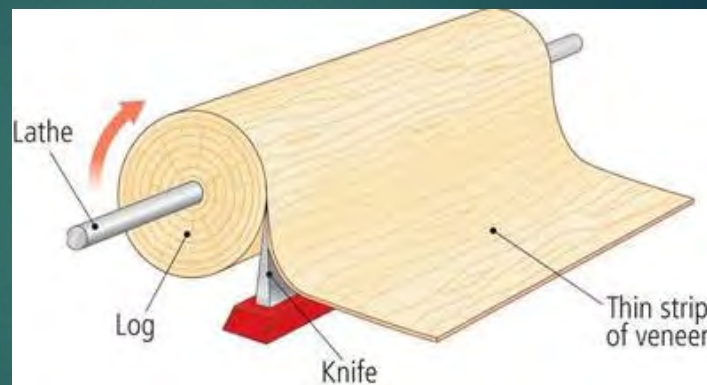
**Table 1A Nominal and Minimum Dressed Sizes of Sawn Lumber**

Item	Thickness (in.)			Face Widths (in.)			
	Nominal	Minimum dressed		Nominal	Minimum dressed		
		Dry	Green		Dry	Green	
Boards	3/4	5/8	11/16	2	1-1/2	1-9/16	
	1	3/4	25/32	3	2-1/2	2-9/16	
	1-1/4	1	1-1/32	4	3-1/2	3-9/16	
	1-1/2	1-1/4	1-1/4	1-9/32	5	4-1/2	4-5/8
					6	5-1/2	5-5/8
					7	6-1/2	6-5/8
					8	7-1/4	7-1/2
					9	8-1/4	8-1/2
					10	9-1/4	9-1/2
					11	10-1/4	10-1/2
					12	11-1/4	11-1/2
					14	13-1/4	13-1/2
					16	15-1/4	15-1/2
	Dimension Lumber	2	1-1/2	1-9/16	2	1-1/2	1-9/16
					3	2-1/2	2-9/16
					4	3-1/2	3-9/16
5					4-1/2	4-5/8	
6					5-1/2	5-5/8	
8					7-1/4	7-1/2	
10					9-1/4	9-1/2	
12					11-1/4	11-1/2	
14					13-1/4	13-1/2	
16					15-1/4	15-1/2	
Timbers	5 & 6 thick	1/2 off	1/2 off	5 & 6 wide	1/2 off	1/2 off	
	7-15 thick	3/4 off	1/2 off	7-15 wide	3/4 off	1/2 off	
	≥16 thick	1 off	1/2 off	≥16 wide	1 off	1/2 off	



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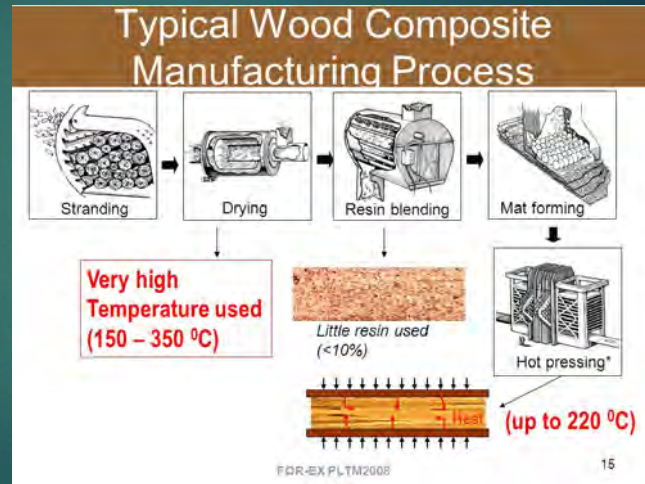
# Veneering



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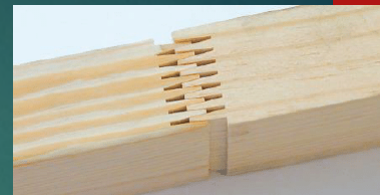


# stranding



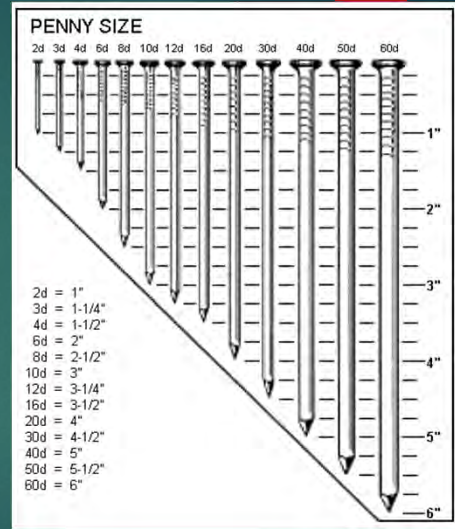
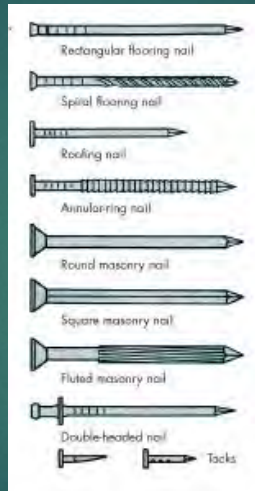
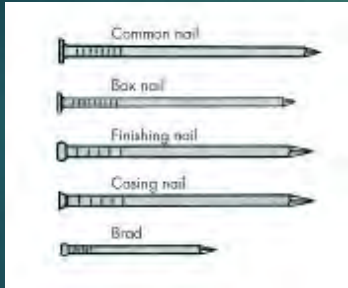
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# Finger Jointing



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# nails



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# bolts



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# screws

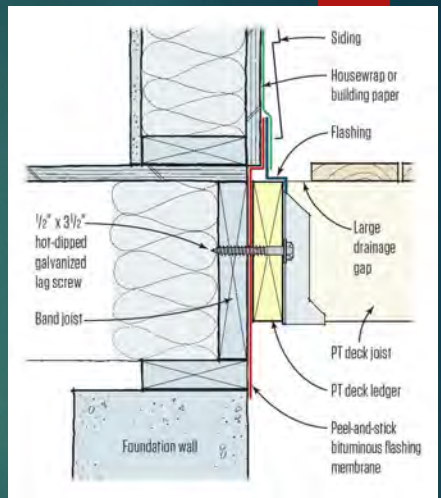
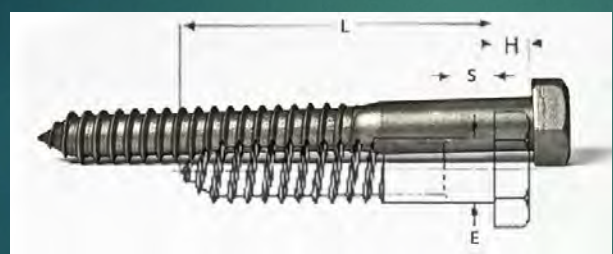
TRADITIONAL WOOD SCREWS											PRODUCTION SCREWS										
Gauge	2	3	4	5	6	7	8	9	10	12	14	4	6	8	10	12	14				
Head-Bore Size	11/84"	13/64"	15/64"	1/8"	9/32"	5/16"	11/32"	23/64"	25/64"	7/16"	1/2"	7/32"	17/64"	11/32"	23/64"	7/16"	1/2"				
Shank-Hole Size	•	•	•	•	•	•	•	•	•	•	•	Shank hole is the same size as the pilot hole listed below									
Pilot-Hole Size	Hardwood	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
	Softwood	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
Available Lengths	1/4"	3/8"	1/2"	5/8"	3/4"	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 5/8"	1 3/4"	2"	2 1/4"	2 1/2"	2 3/4"	3"	3 1/4"	3 1/2"	3 3/4"	4"
Phillips-Head Point Size	#1					#2			#3			#1	#2		#3						
Square-Drive Bit Size	#0					#1			#2			#0	#1	#2		#3					

WOOD® Magazine - <http://www.woodmagazine.com>



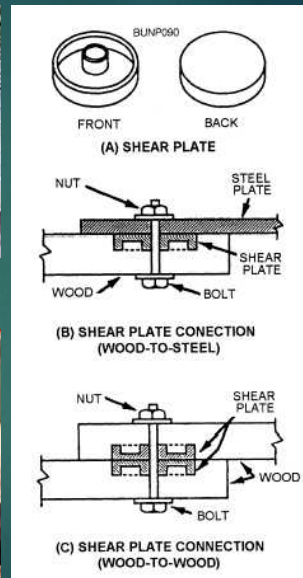
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# lags



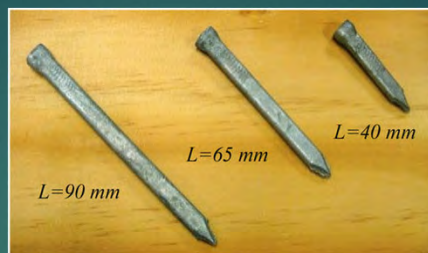
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# Split rings



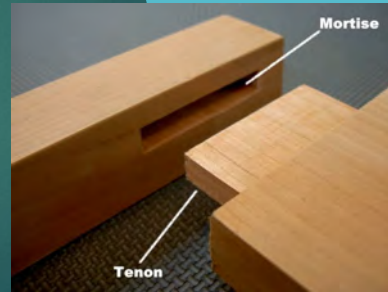
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# Timber rivets



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# Mortise & Tendon/ dovetail



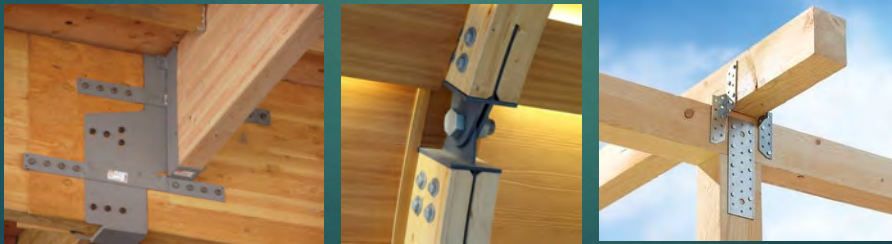
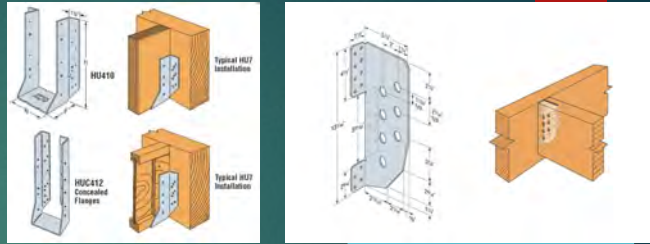
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# Tongue & Grove/Spline



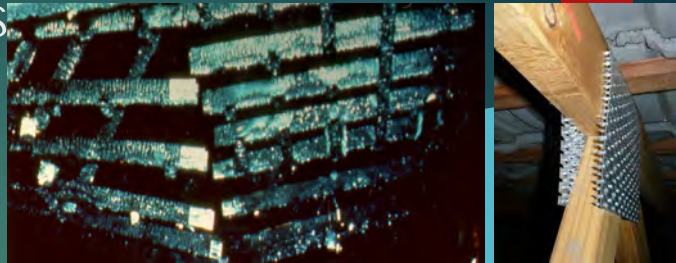
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# Engineered connections



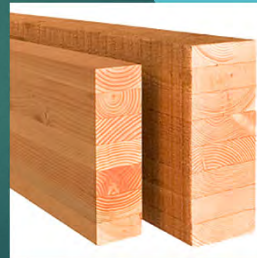
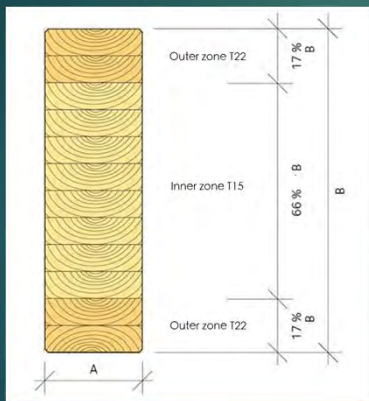
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# Metal truss plates



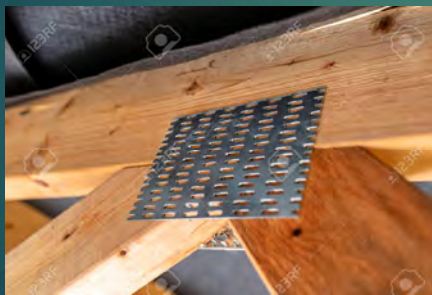
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## Glued laminated timber/ Gluelam

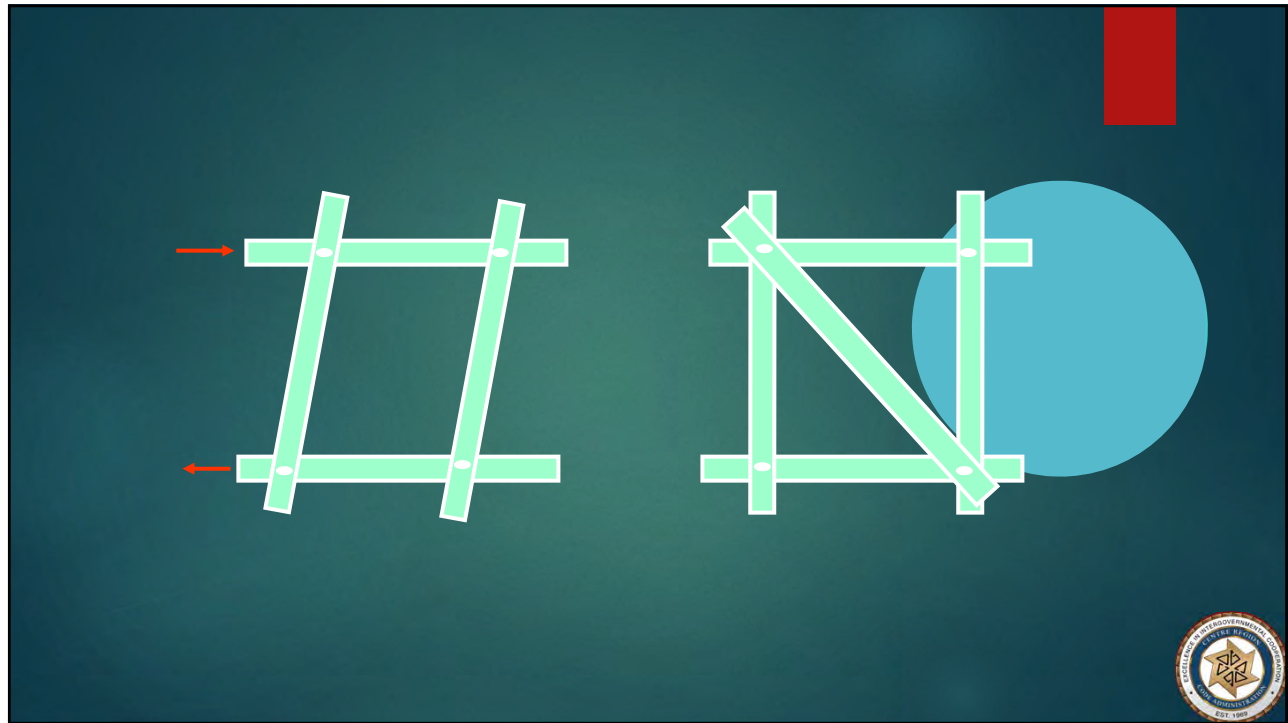


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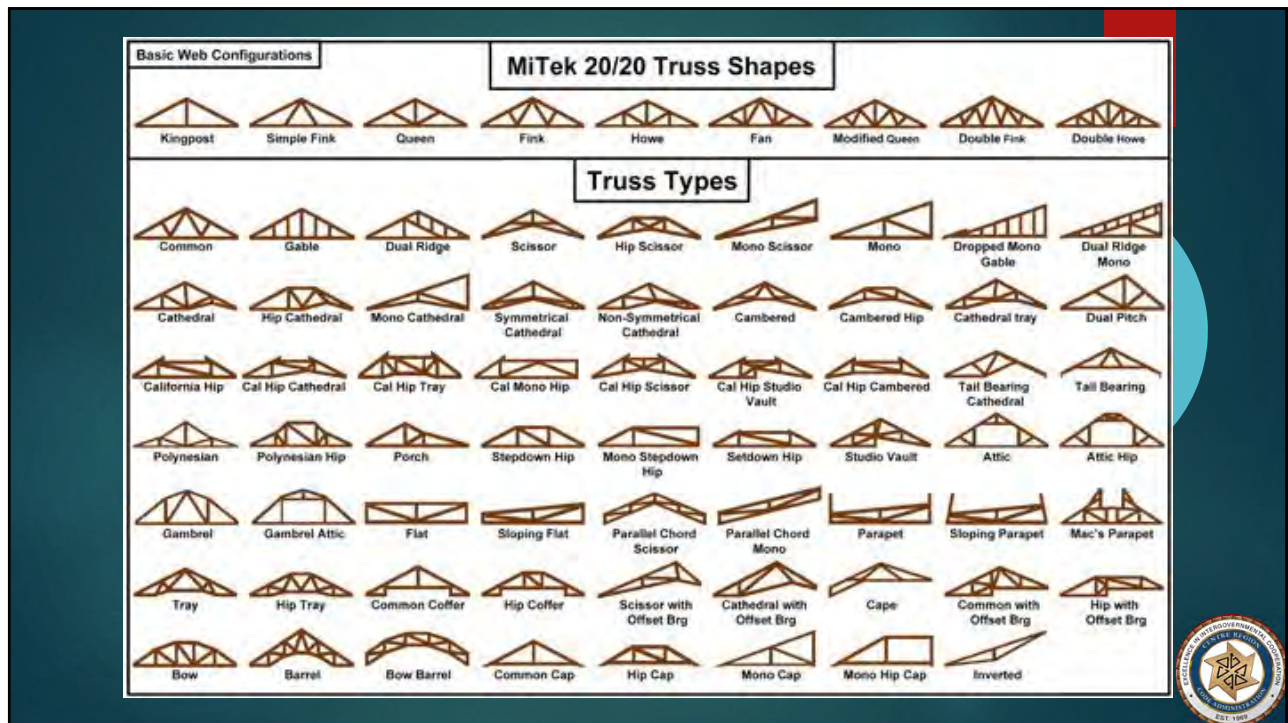
## Metal plate trusses



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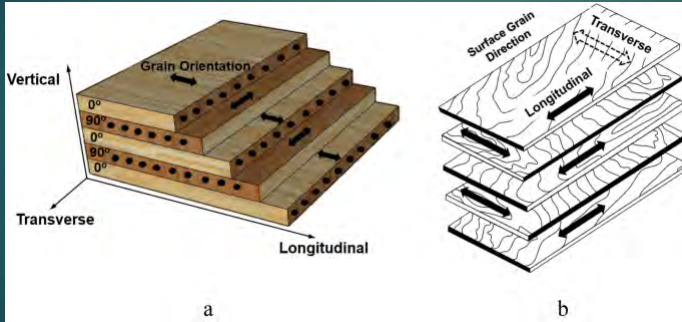
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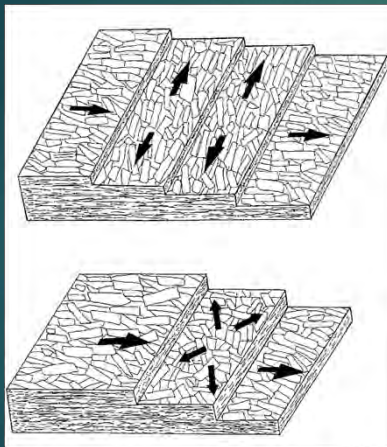


# Plywood



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# Oriented Strand Board (OSB)



Actual Size: 0.406-in x 3.98-ft x 7.98-ft



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# Laminated Veneer Lumber (LVL)



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# Parallel Stranded Lumber (PSL)



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## Laminated stranded lumber (LSL)



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## Oriented Stranded Lumber

- ▶ Oriented Strand Lumber (OSL). Oriented strand lumber (OSL) is closely related to LSL being made with strands of wood but having a shorter length to width ratio of 75:1. The strands are bonded with a resin in a steam pressing process. OSL is typically used for building studs (Figure 7.xx OSL).



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# I - Joist



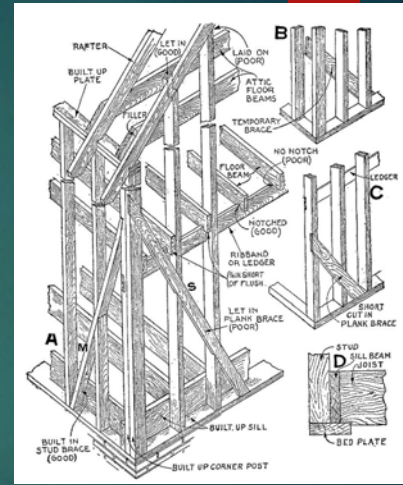
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# Cross laminated timber (CLT)



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# Balloon frame

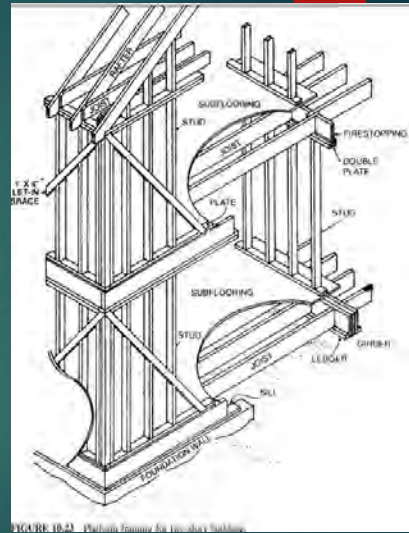


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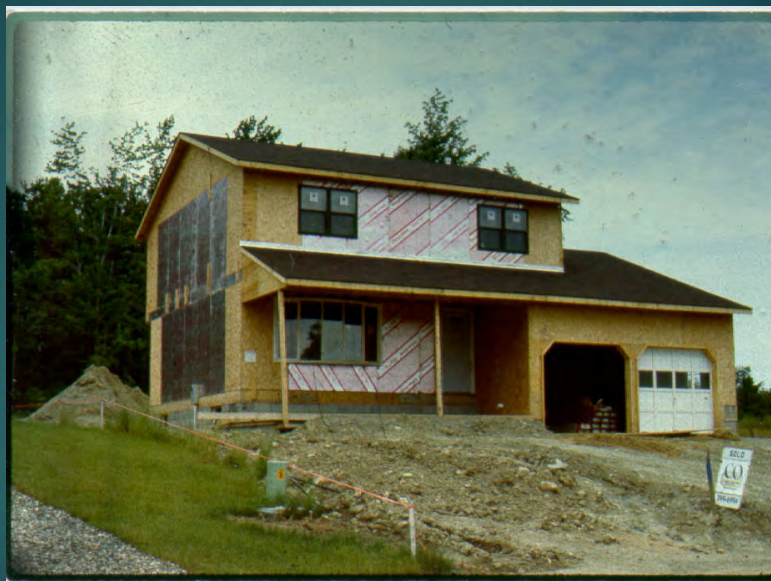


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# Platform frame



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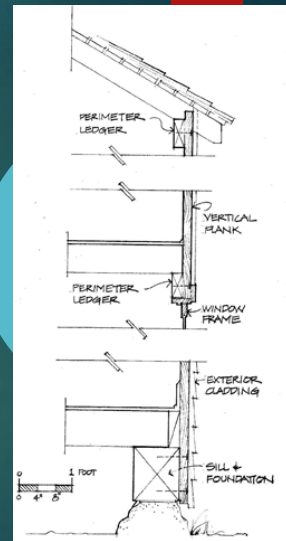


# Log



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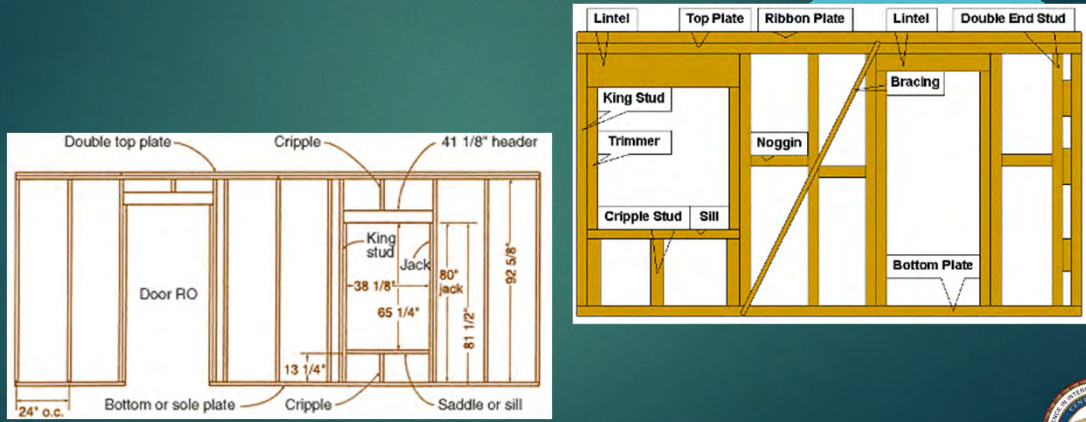
# Plank



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# Load-Bearing Wall & Plate



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# Concrete/ Reinforced Concrete



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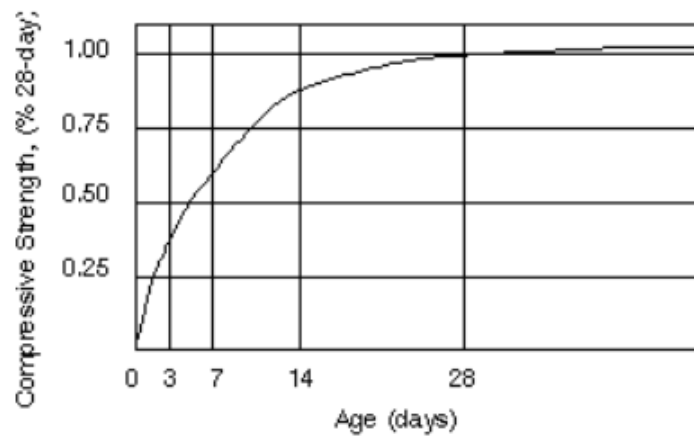
## Constituent parts

- ▶ Portland Cement
- ▶ Water
- ▶ Large Aggregate - gravel
- ▶ Fine Aggregate – sand
- ▶ Air
- ▶ Admixtures
- ▶ Reinforcement



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## Curing & Strength Development



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# Cast-in-place site cast concrete



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# Precast concrete

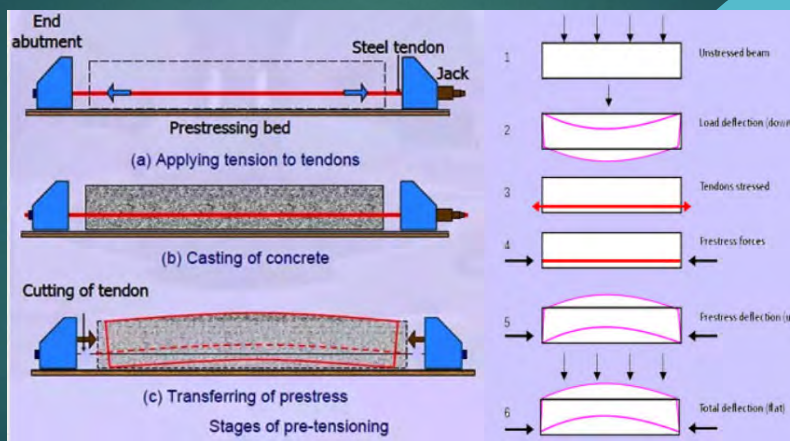


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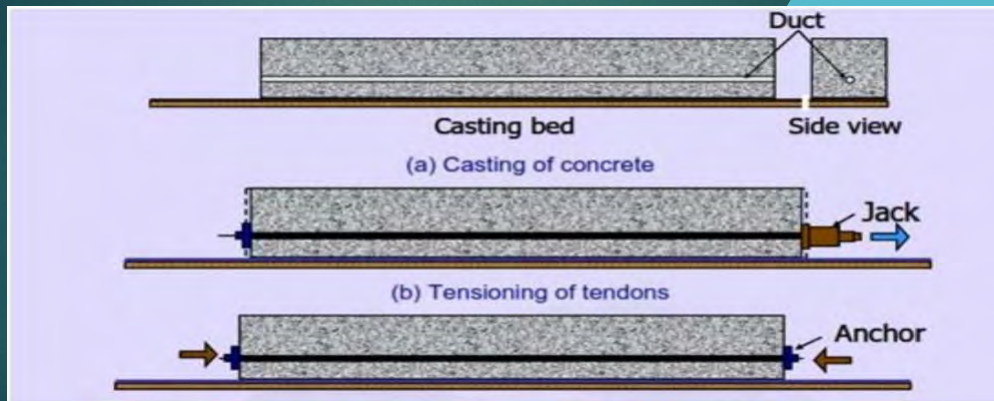
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# Pre-Stressed



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# Post-tensioned



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# Post-Tensioned



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# Tilt-Up

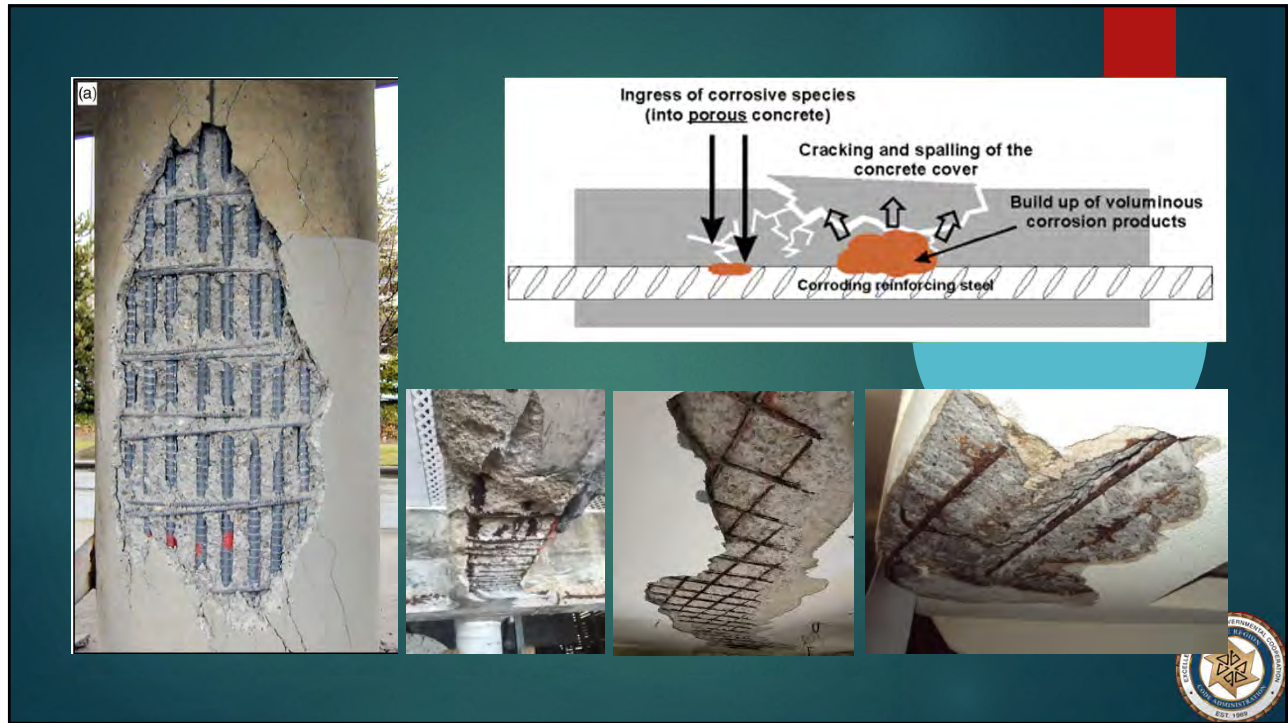


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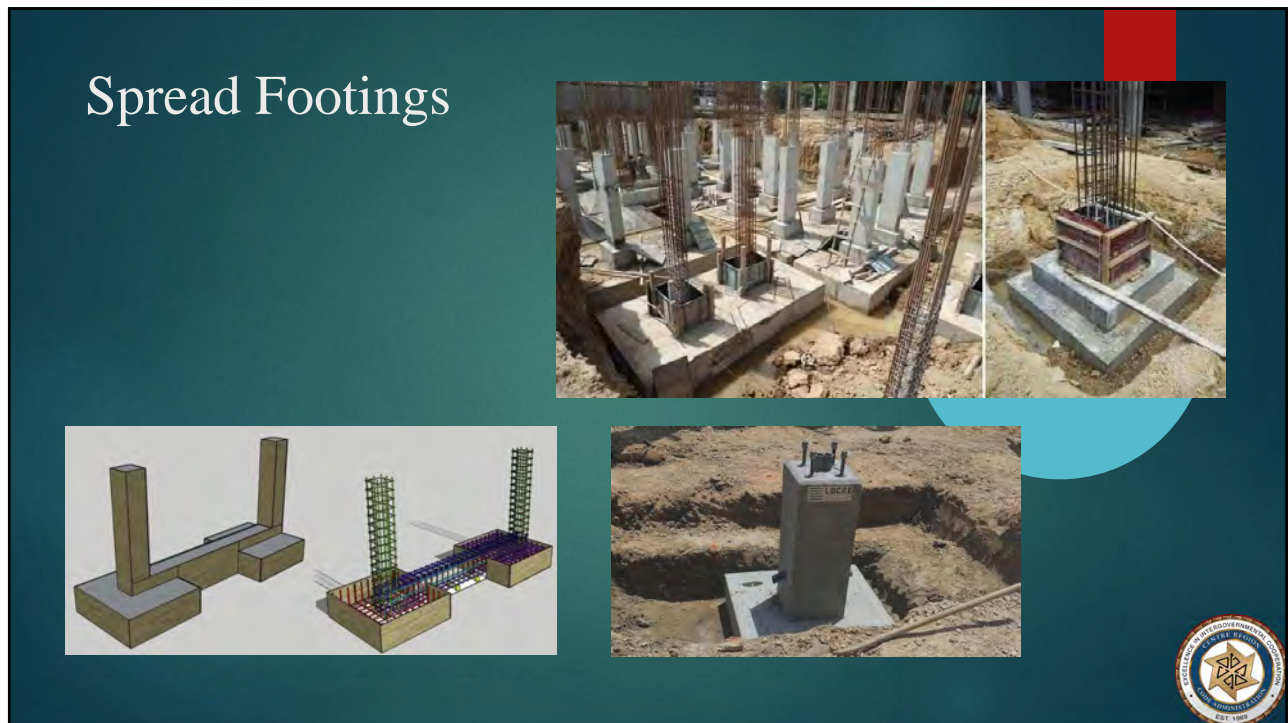
# Lift slab construction



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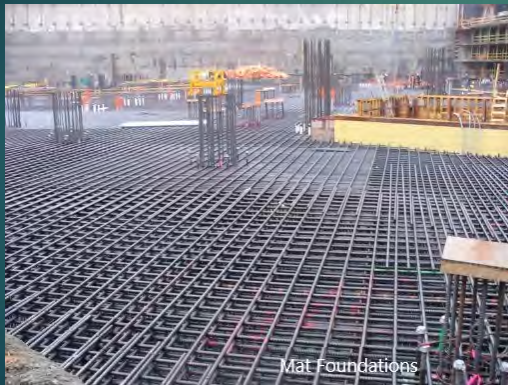


# Strip Footings



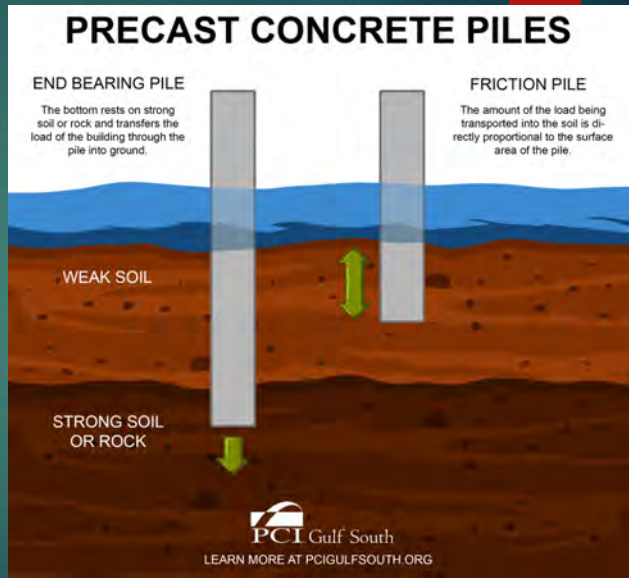
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# Mat/Raft Foundation

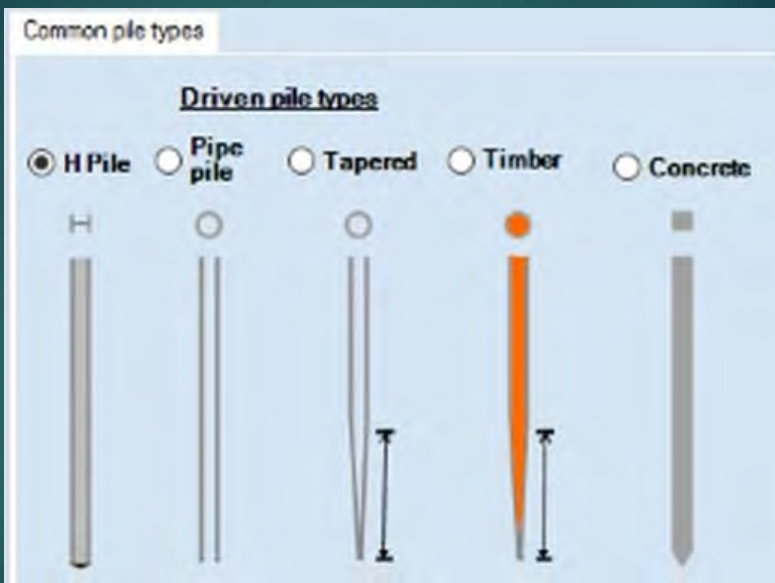


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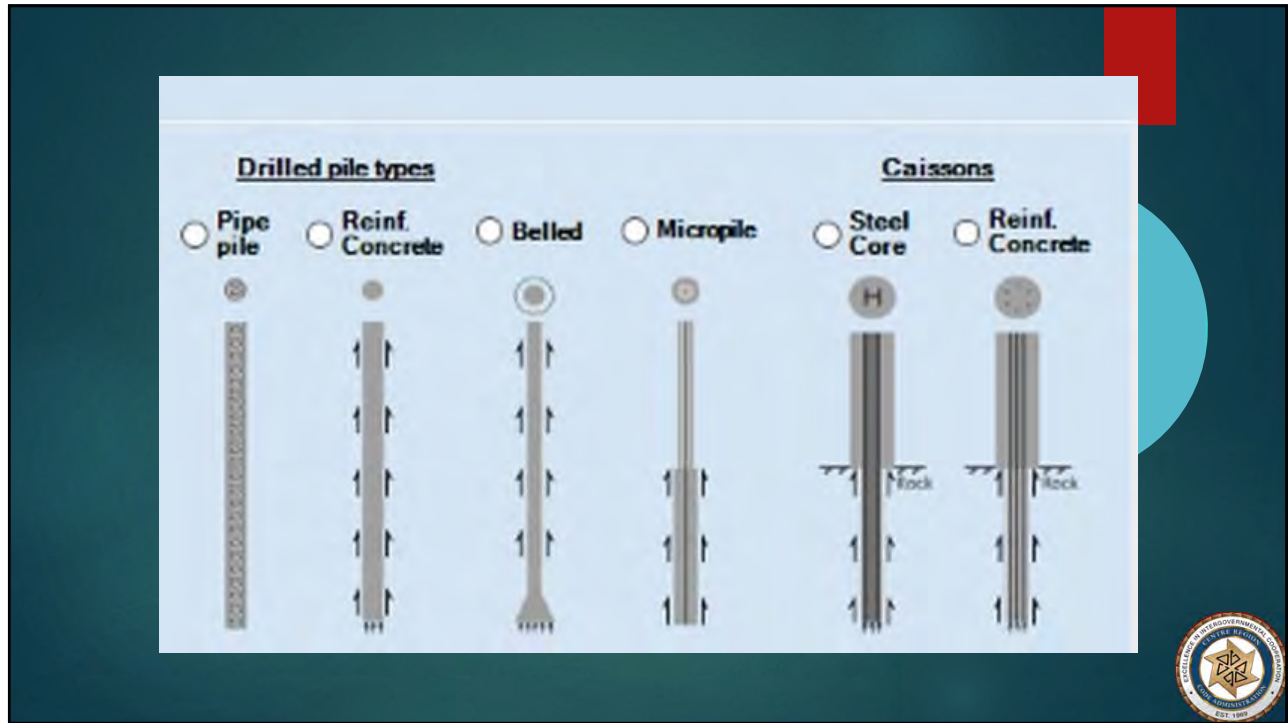
# Piles



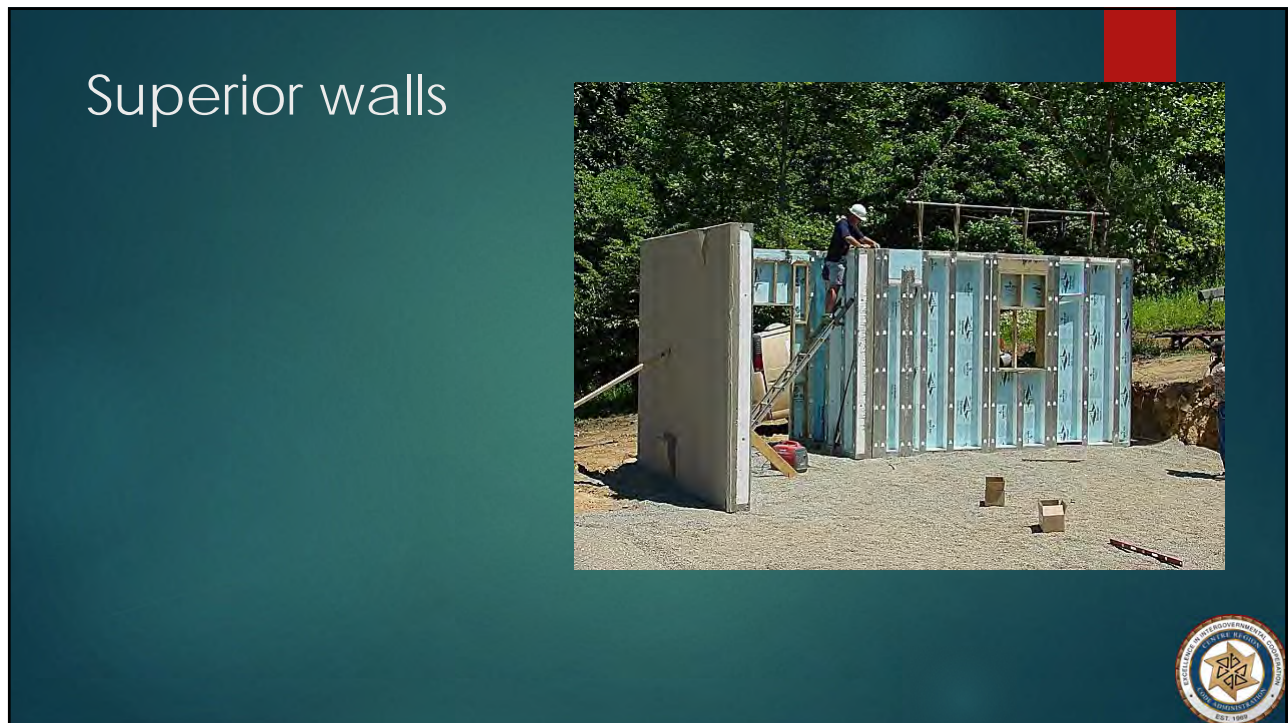
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## One Way & Two Way Slabs

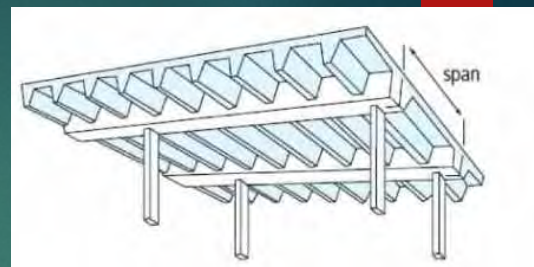


1 : 2

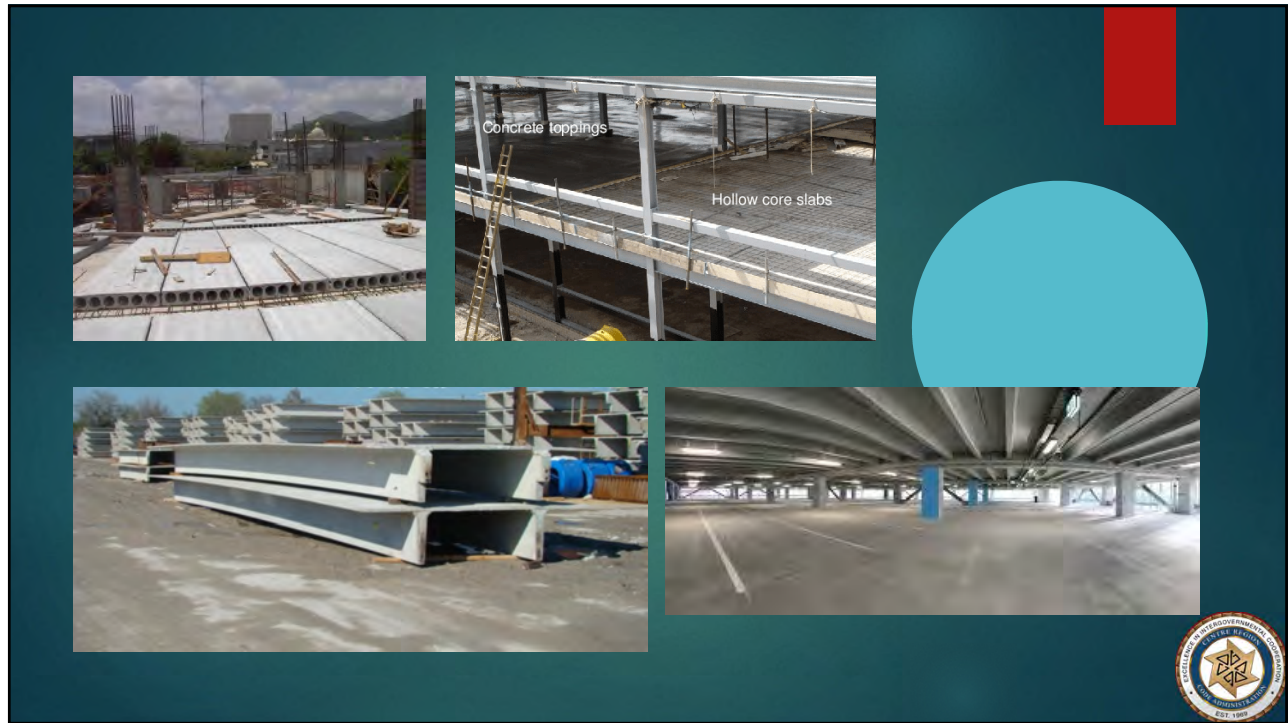


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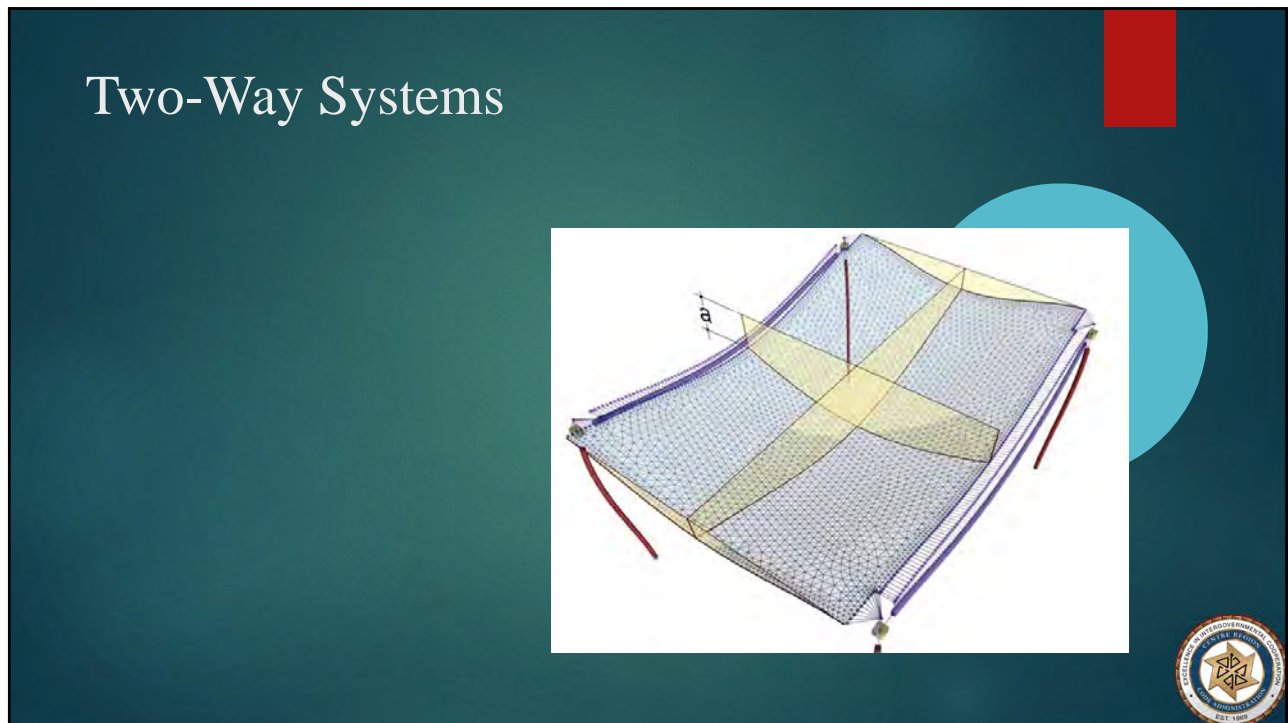
## One-Way Systems



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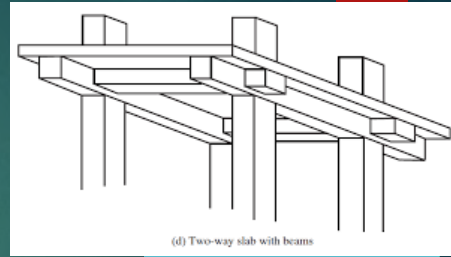


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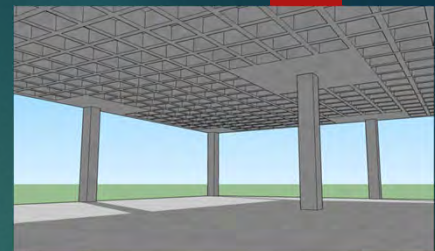
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# Beam supported slab

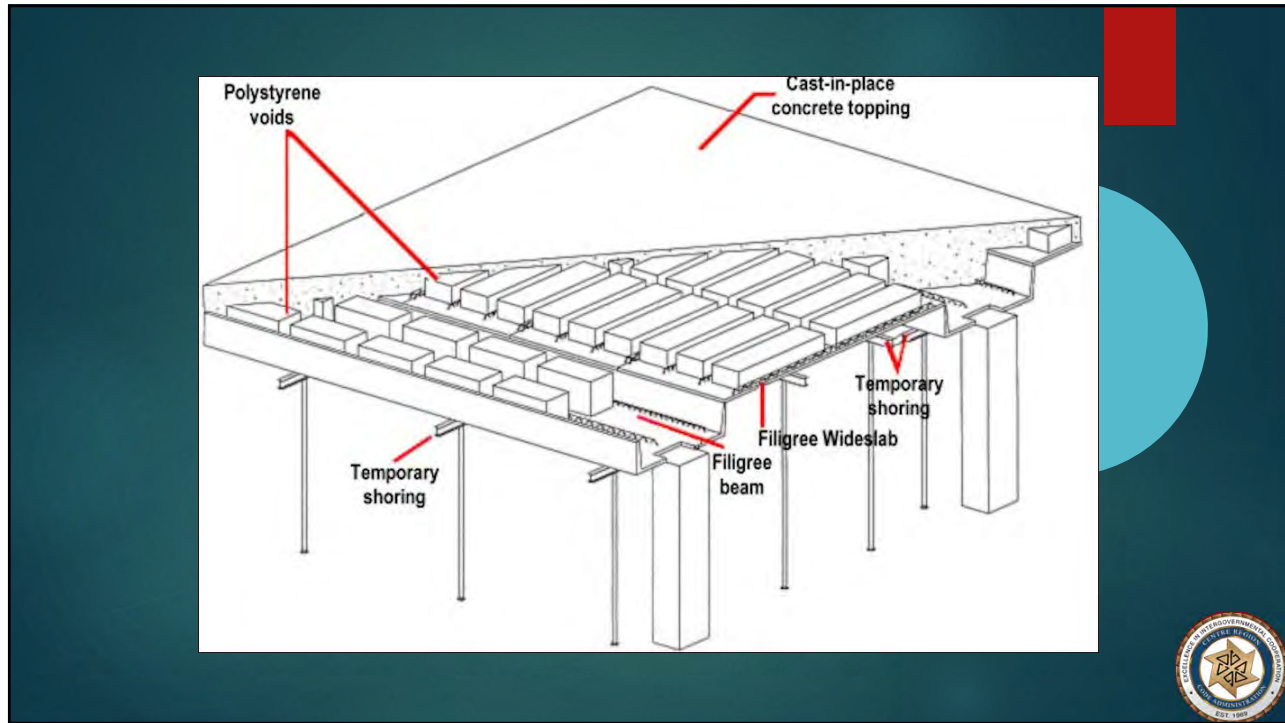


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# Waffle Slab



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## Flat Slab

- ▶ Flat Slab
- ▶ Flat Slab with Drop Panel
- ▶ Flat Slab with column Heads
- ▶ Flat Slab with Column Heads & Drop Panels

*Flat Slab resting directly on columns*

*Flat Slab with drop panels*

*Flat slab with drop panel and column head*

*Flat slab with column head*

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# Flat Plate / Flat Slab



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# Insulated concrete form (ICF)



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# mortar

### Guide for Selecting the Right Mortar Type

Mortar Type						
<b>N</b> 						
	above grade	exterior	interior	load-bearing	soft stone masonry	
<b>O</b> 						
	above grade	interior	non load-bearing			
<b>S</b> 						
	below grade	masonry foundations	manholes	retaining walls	sewers	brick patios & pavements
<b>M</b>  the balance						
	heavy loads	masonry below grade	foundations	retaining walls	driveways	

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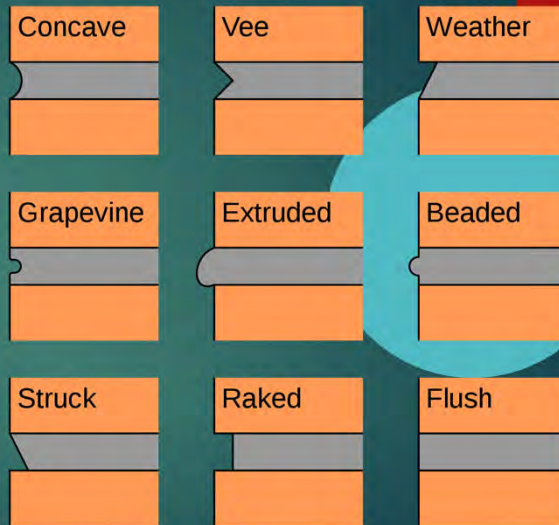
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# Historic/Lime-Based

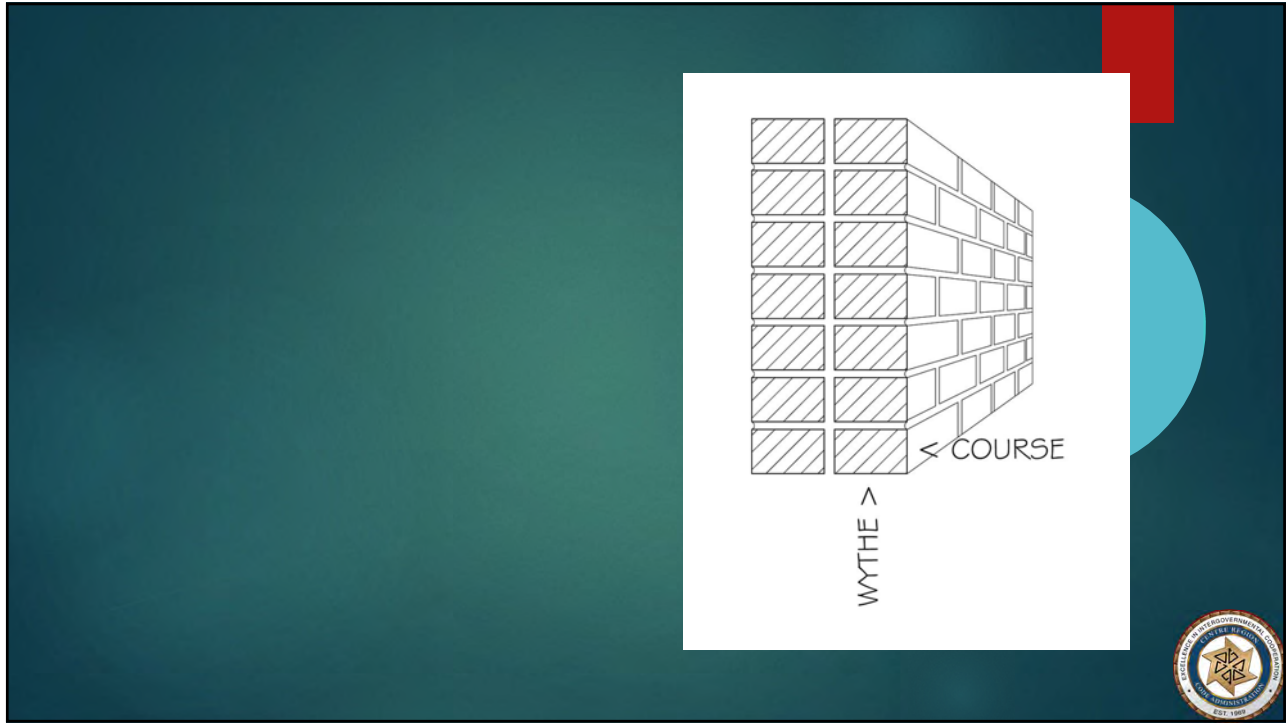


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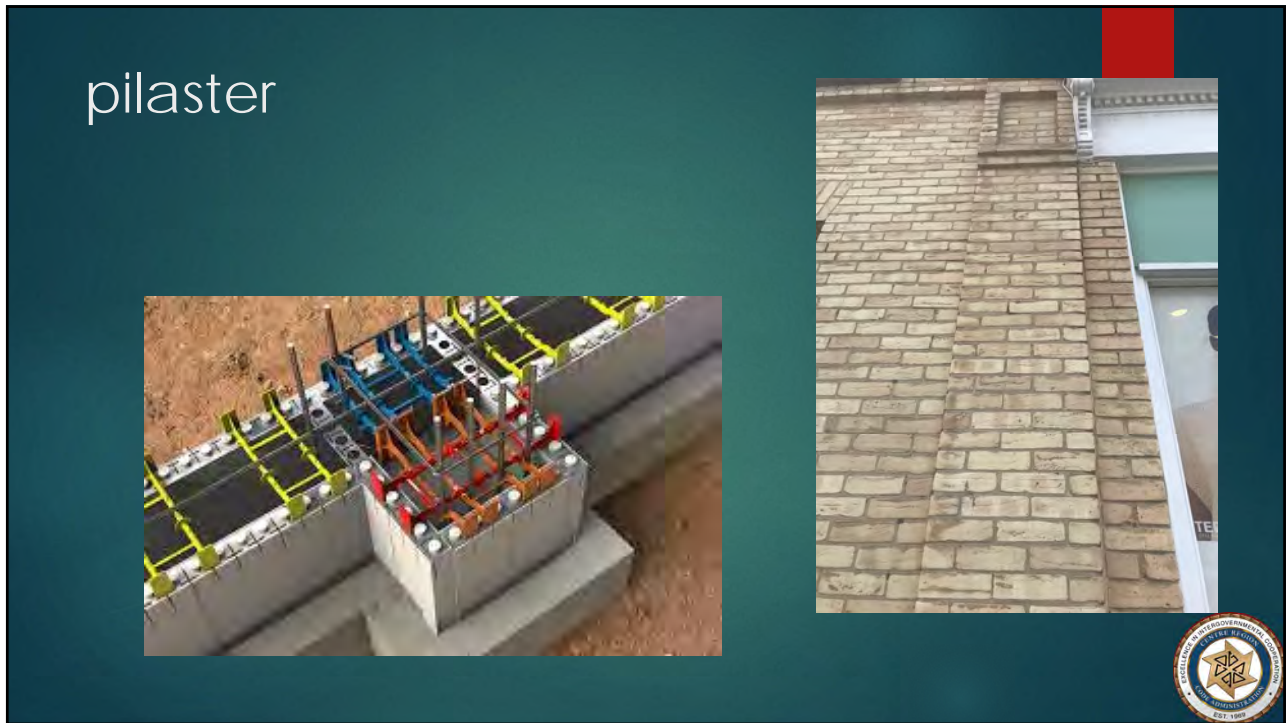
# joints



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# Grout

MORTAR VERSUS GROUT	
Mortar	Grout
It is more stiffer	It is less stiffer
Made of lime, water, sand and cement	Made of cement, water and sand
Binds bricks, stones	Acts as a filler in between tiles
Serves as a tile bed	Serves as the filler
Available in fewer colors	Available in many colors
Applied with trowel	Cannot be applied with trowel because of its large amounts of water



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# Masonry types

- ▶ Veneer
- ▶ Solid / Load-Bearing



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**Solid masonry walls**  
cross sectional view

single wythe

2 wythes running bond (no headers) (uses metal ties)

2 wythes common bond (headers every 6th course)

2 wythes common bond (6th course headers) (cinder block used for inside face of wall)

3 wythes common bond (headers every 6th course)

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# Units

- ▶ Stone
- ▶ Structural Clay tile
- ▶ Brick
- ▶ Concrete Masonry Units(CMU)

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# Structural clay tile Structural Terra Cotta clay Block







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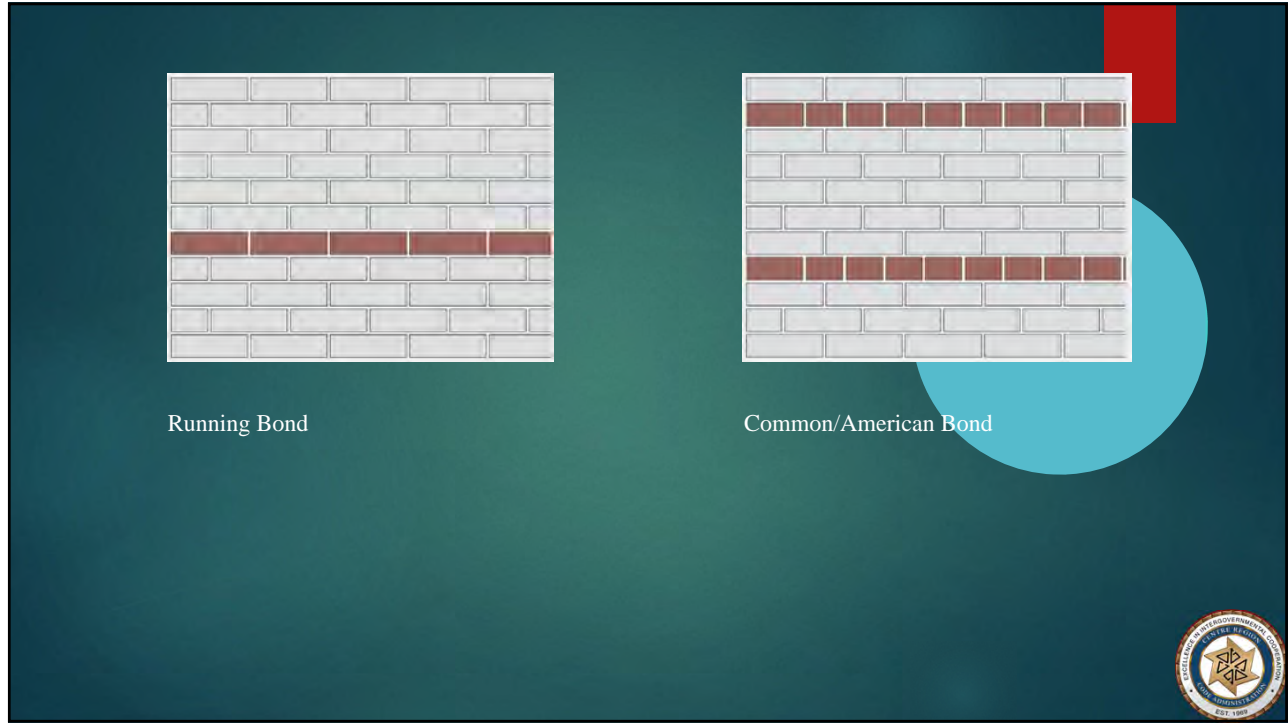
# Brick

## Brick Sizes: 3/8" Mortar Joint Between Bricks (Most Common)

BRICK TYPE	SPECIFIED SIZE D X H X L (INCHES)	NOMINAL SIZE D X H X L	VERTICAL COURSE
Standard	3 5/8 x 2 1/4 x 8	Not modular	3 courses = 8"
Modular	3 5/8 x 2 1/4 x 7 5/8	4 x 2 2/3 x 8	3 courses = 8"
Norman	3 5/8 x 2 1/4 x 11 5/8	4 x 2 2/3 x 12	3 courses = 8"
Roman	3 5/8 x 1 5/8 x 11 5/8	4 x 2 x 12	1 course = 2"
Jumbo	3 5/8 x 2 3/4 x 8	4 x 3 x 8	1 course = 3"
Economy	3 5/8 x 3 5/8 x 7 5/8	4 x 4 x 8	1 course = 4"
Engineer	3 5/8 x 2 13/16 x 7 5/8	4 x 3 1/5 x 8	5 courses = 16"
King	2 3/4 x 2 5/8 x 9 5/8	Not modular	5 courses = 16"
Queen	2 3/4 x 2 3/4 x 7 5/8	Not modular	5 courses = 16"
Utility	3 5/8 x 3 5/8 x 11 5/8	4 x 4 x 12	1 course = 4"



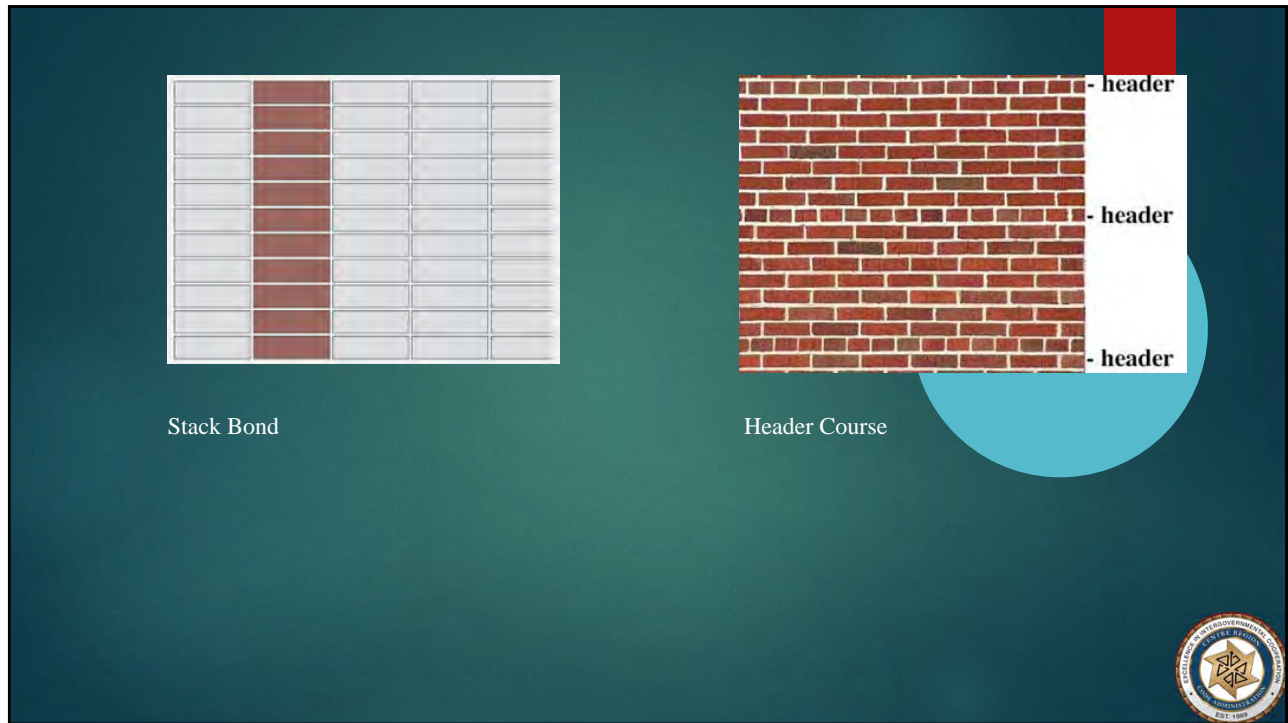
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Running Bond

Common/American Bond

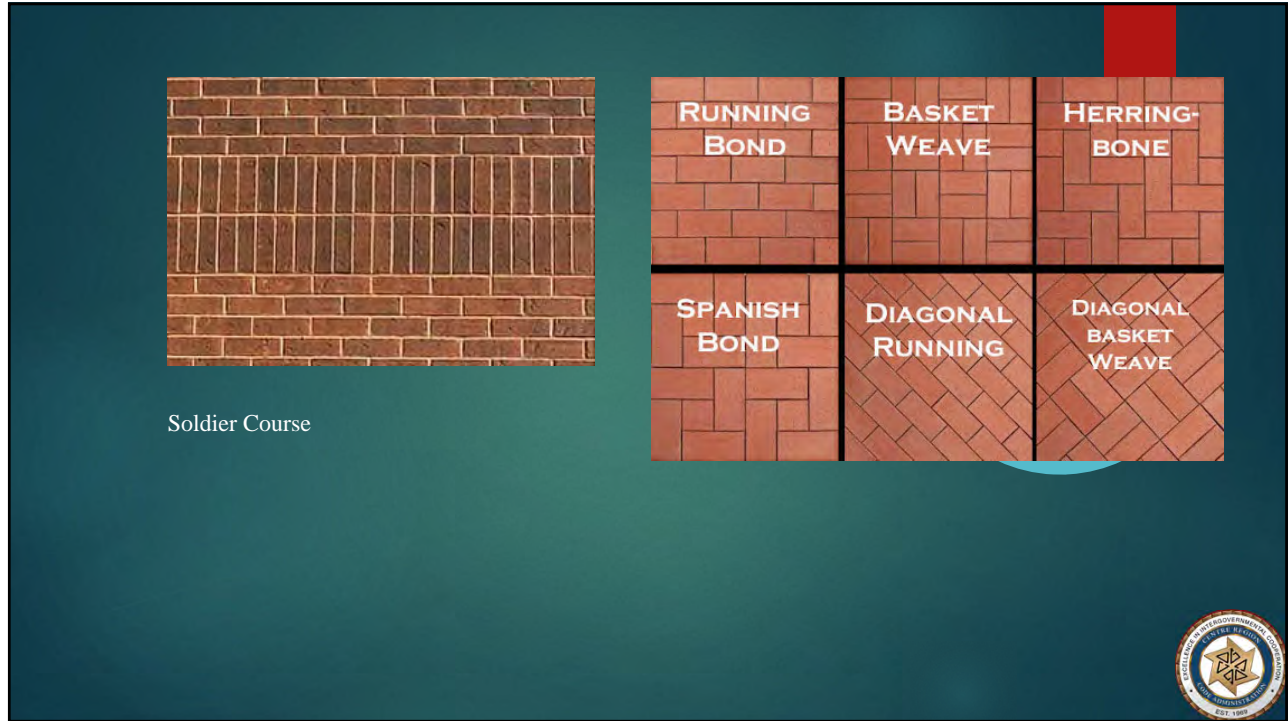
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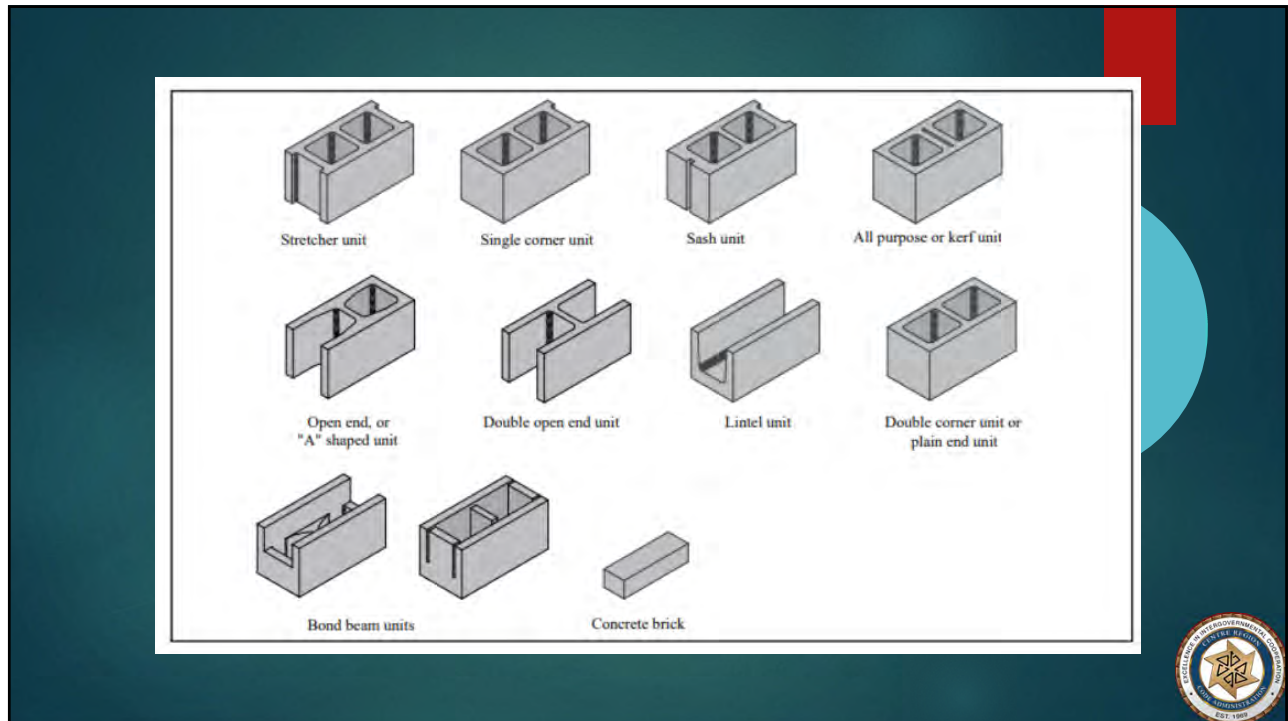
Stack Bond

Header Course

94



95



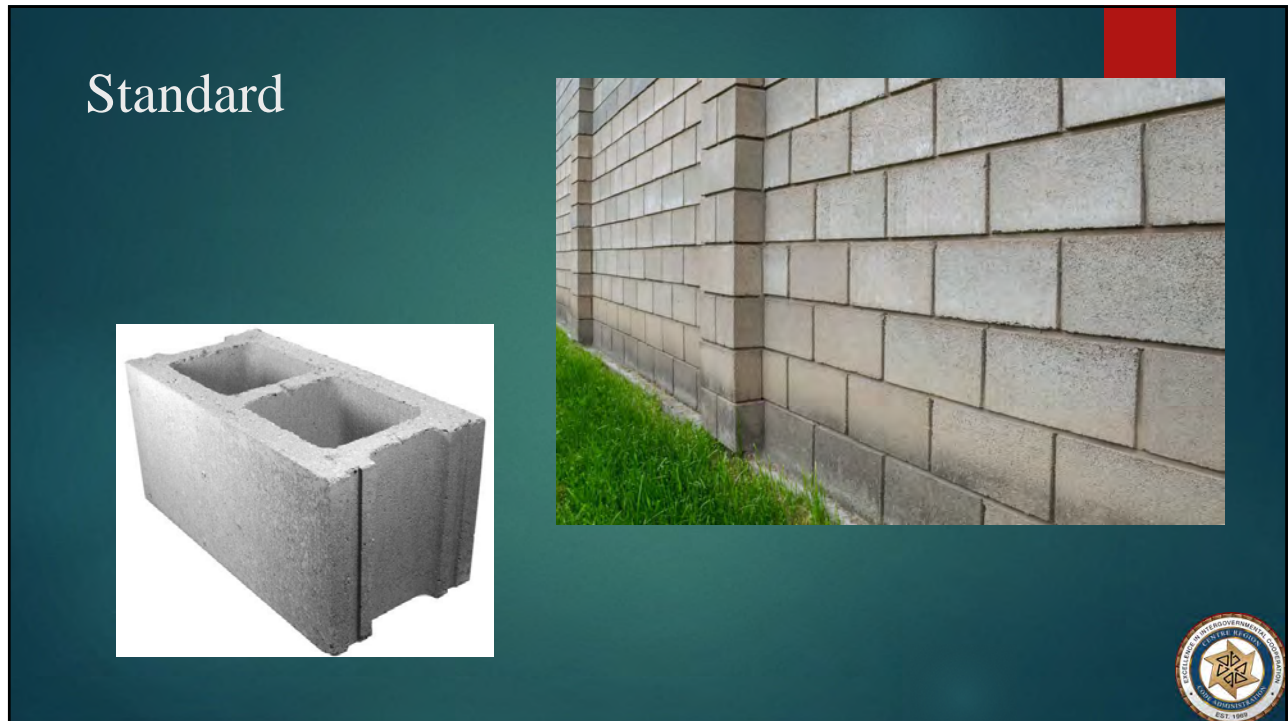
96



CMU SIZE	NOMINAL DIMENSIONS D X H X L	ACTUAL DIMENSIONS D X H X L
4" CMU Full Block	4" x 8" x 16"	3 5/8" x 7 5/8" x 15 5/8"
4" CMU Half-Block	4" x 8" x 8"	3 5/8" x 7 5/8" x 7 5/8"
6" CMU Full Block	6" x 8" x 16"	5 5/8" x 7 5/8" x 15 5/8"
6" CMU Half-Block	6" x 8" x 8"	5 5/8" x 7 5/8" x 7 5/8"
8" CMU Full Block	8" x 8" x 16"	7 5/8" x 7 5/8" x 15 5/8"
8" CMU Half-Block	8" x 8" x 8"	7 5/8" x 7 5/8" x 7 5/8"
10" CMU Full Block	10" x 8" x 16"	9 5/8" x 7 5/8" x 15 5/8"
10" CMU Half-Block	10" x 8" x 8"	9 5/8" x 7 5/8" x 7 5/8"
12" CMU Full Block	12" x 8" x 16"	11 5/8" x 7 5/8" x 15 5/8"
12" CMU Half-Block	12" x 8" x 8"	11 5/8" x 7 5/8" x 7 5/8"

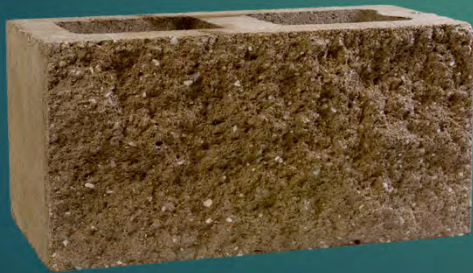


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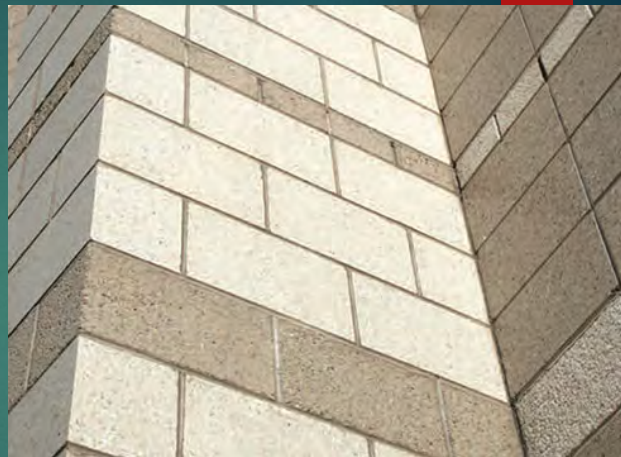
98

# Split faced



99

# Ground Faced



100

# Structural Glazed Tile

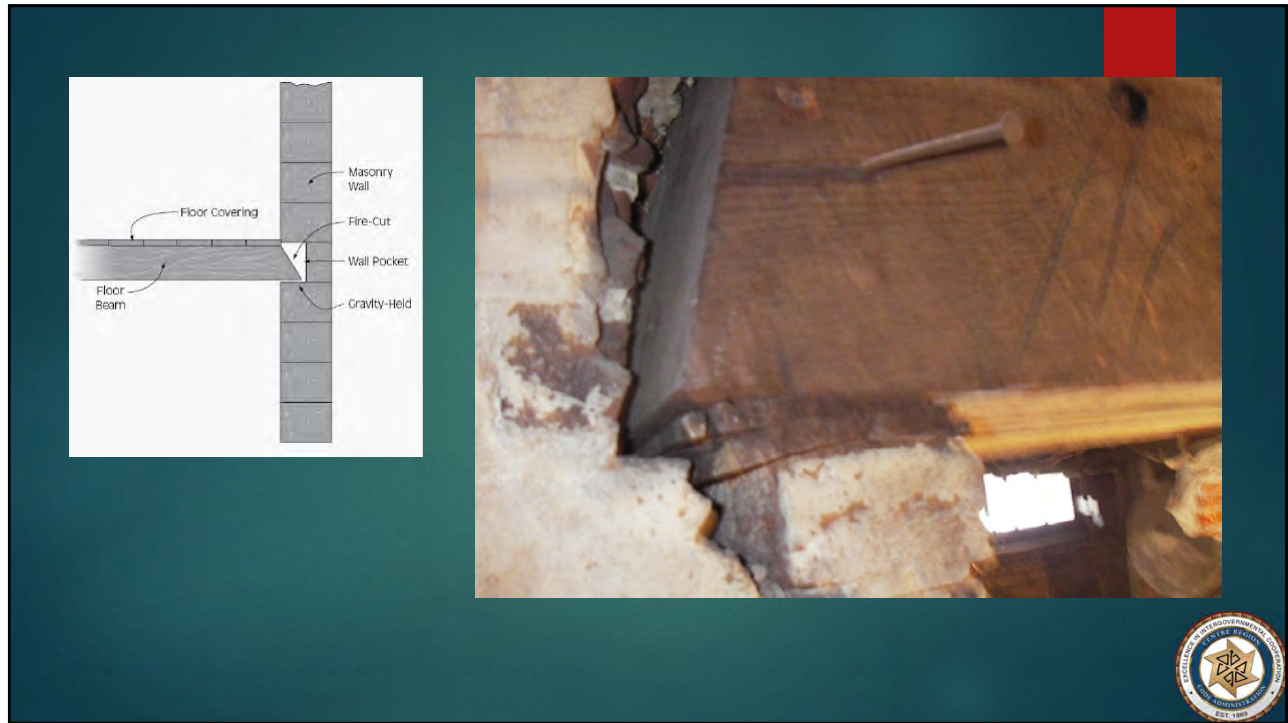


101

# Beam pockets



102



103



104



105

# lintels

*Figure 1 - How a Steel Lintel is Installed*

106

# Parapet Walls



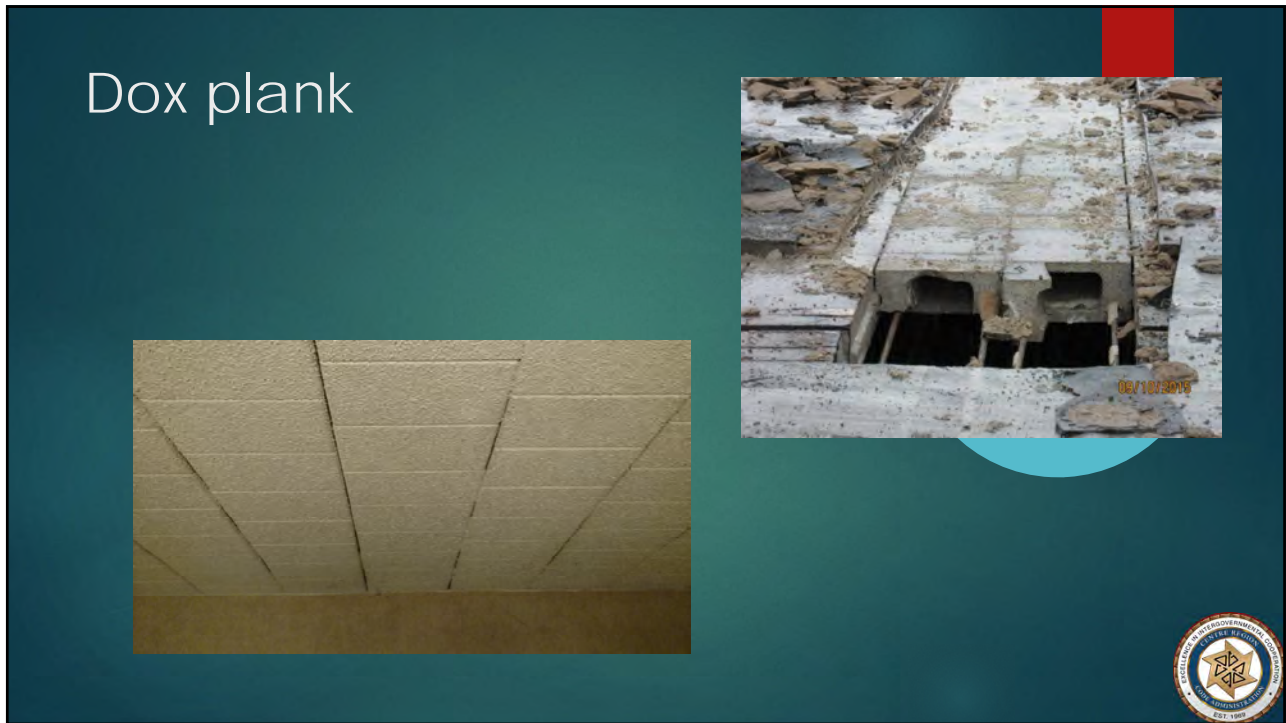
107



108



109



110

## Wrought Iron



111

## Properties

- ▶ Low carbon content less than 0.08%
- ▶ Malleable
- ▶ Ductile
- ▶ Corrosion resistant
- ▶ Easily welded
- ▶ Typically worked hot
- ▶ Melting point – 2,800°F



112



## Uses prior to 1860's

- ▶ Nails
- ▶ Bolts/nuts
- ▶ Connections for timber
- ▶ Rivets
- ▶ Wire
- ▶ Chain
- ▶ Ornamental ironwork



113

## Cast Iron



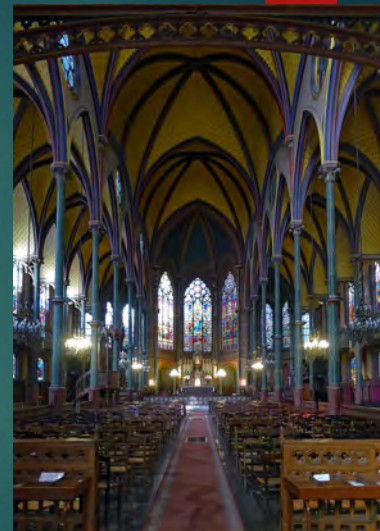
114

# Properties

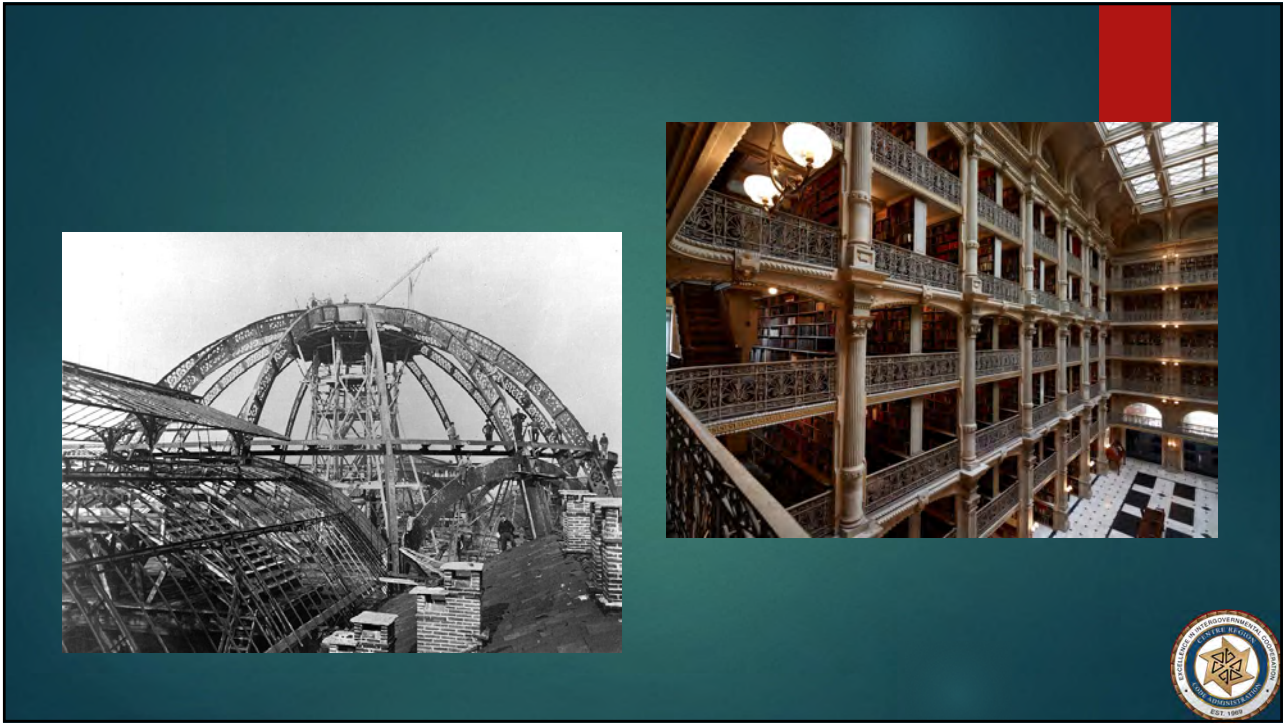
- ▶ Carbon content between 2% and 4%
- ▶ Weight 450 pcf
- ▶ Brittle
- ▶ Strong in compression
- ▶ Weak in tension
- ▶ Melting point – 2,100°F



115



116



117



118

# properties

- ▶ Carbon content between 0.6% and 2%
- ▶ Weight 490 pcf
- ▶ Isotropic
- ▶ Ductile
- ▶ Homogeneous
- ▶ Melting point – 2,500°F



119

# Hot Rolled/Red Iron



120

# Shapes

ANGLE (L-SHAPE)      DOUBLE ANGLE      MT-SHAPE      WT-SHAPE      ST-SHAPE

CHANNLE (C-SHAPE)      MC-SHAPE      PIPE      ROUND TUBE (HSS)      RECT. TUBE (HSS)

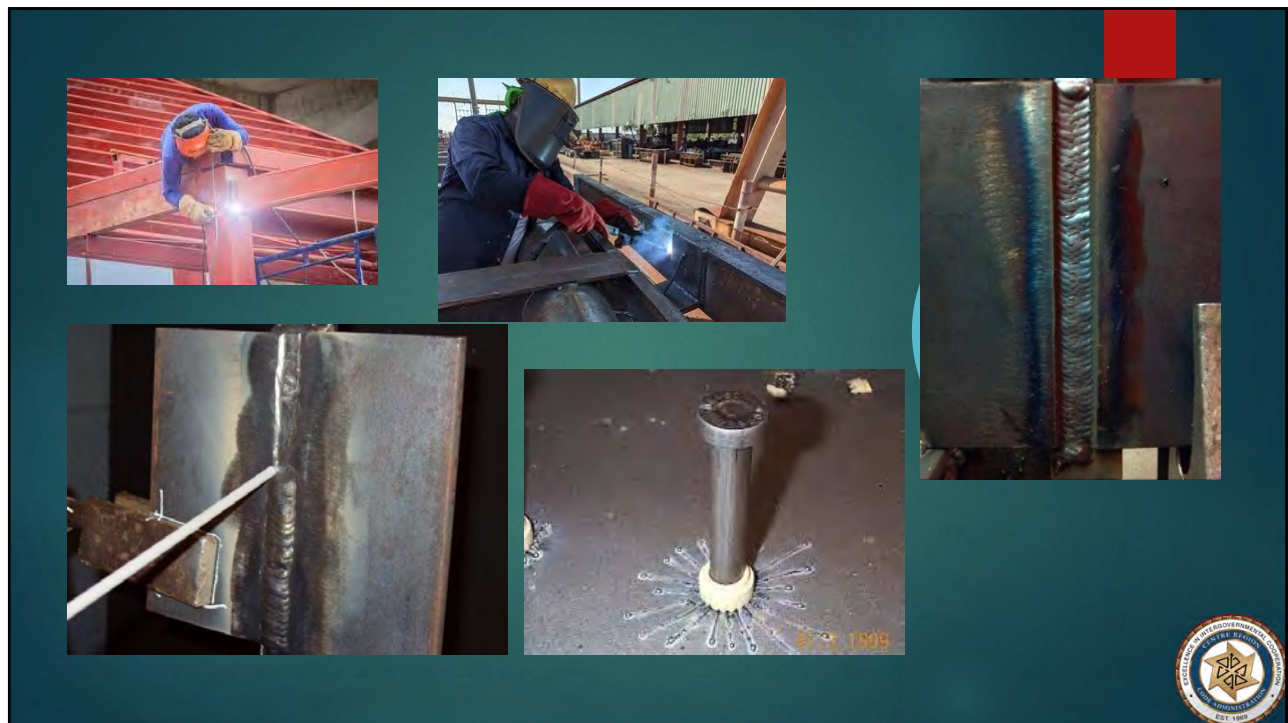
WIDE FLANGE (W-SHAPE)      S-SHAPE      M-SHAPE      HP-SHAPE

121

122



123

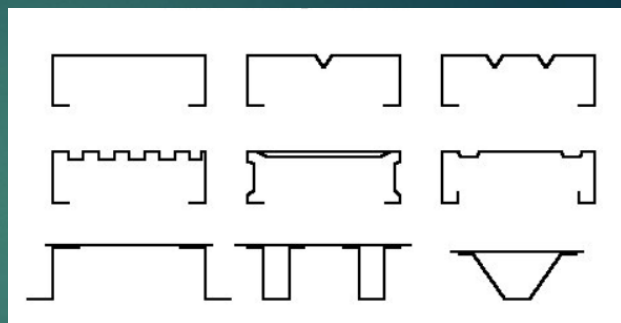
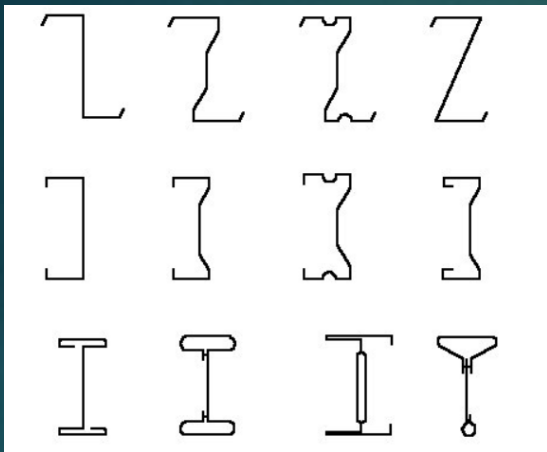


124

# Cold-Formed



125



126

Sheet Metal Gauge Guide				
Gauge	Steel (mm)	Galvanized (mm)	Stainless (mm)	Aluminum (mm)
3	0.2391 (6.07)	--	--	--
4	0.2242 (5.69)	--	--	--
5	0.2092 (5.31)	--	--	--
6	0.1943 (4.94)	--	--	0.162 (4.1)
7	0.1793 (4.55)	--	0.1875 (4.76)	0.1443 (3.67)
8	0.1644 (4.18)	0.1681 (4.27)	0.1719 (4.37)	0.1285 (3.26)
9	0.1495 (3.80)	0.1532 (3.89)	0.1563 (3.97)	0.1144 (2.91)
10	0.1345 (3.42)	0.1382 (3.51)	0.1406 (3.57)	0.1019 (2.59)
11	0.1196 (3.04)	0.1233 (3.13)	0.1250 (3.18)	0.0907 (2.30)
12	0.1046 (2.66)	0.1084 (2.75)	0.1094 (2.78)	0.0808 (2.05)
13	0.0897 (2.28)	0.0934 (2.37)	0.0940 (2.40)	0.0720 (1.80)
14	0.0747 (1.90)	0.0785 (1.99)	0.0781 (1.98)	0.0641 (1.63)
15	0.0673 (1.71)	0.0710 (1.80)	0.0700 (1.80)	0.0570 (1.40)
16	0.0598 (1.52)	0.0635 (1.61)	0.0625 (1.59)	0.0508 (1.29)
17	0.0538 (1.37)	0.0575 (1.46)	0.0560 (1.40)	0.0450 (1.10)
18	0.0478 (1.21)	0.0516 (1.31)	0.0500 (1.27)	0.0403 (1.02)
19	0.0418 (1.06)	0.0456 (1.16)	0.0440 (1.10)	0.0360 (0.91)
20	0.0359 (0.91)	0.0396 (1.01)	0.0375 (0.95)	0.0320 (0.81)
21	0.0329 (0.84)	0.0366 (0.93)	0.0340 (0.86)	0.0280 (0.71)
22	0.0299 (0.76)	0.0336 (0.85)	0.0310 (0.79)	0.0250 (0.64)
23	0.0269 (0.68)	0.0306 (0.78)	0.0280 (0.71)	0.0230 (0.58)
24	0.0239 (0.61)	0.0276 (0.70)	0.0250 (0.64)	0.0200 (0.51)
25	0.0209 (0.53)	0.0247 (0.63)	0.0220 (0.56)	0.0180 (0.46)
26	0.0179 (0.45)	0.0217 (0.55)	0.0190 (0.48)	0.0170 (0.43)
28	0.0149 (0.38)	0.0187 (0.47)	0.0160 (0.41)	0.0126 (0.32)

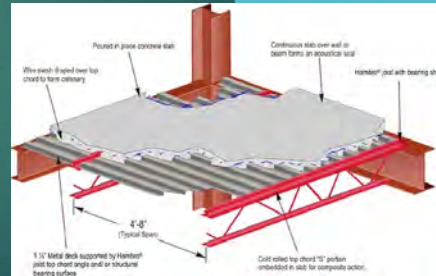
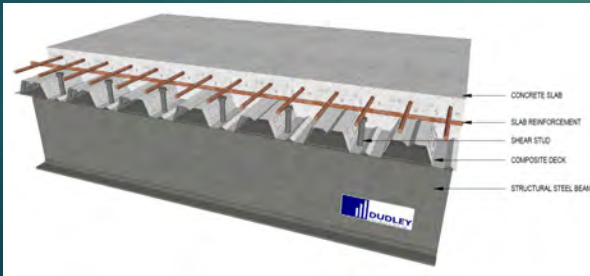
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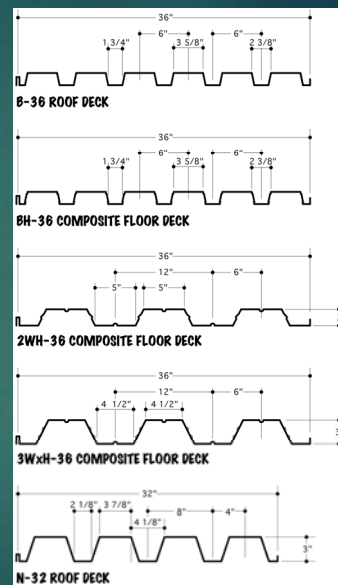
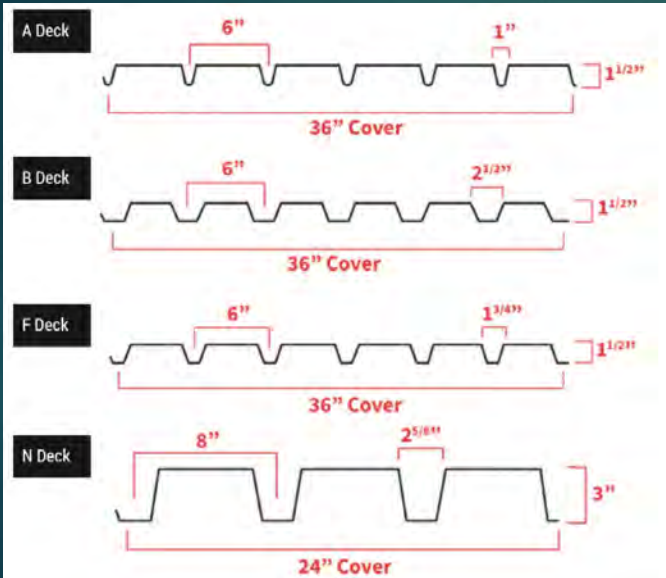
128



# Metal Decking



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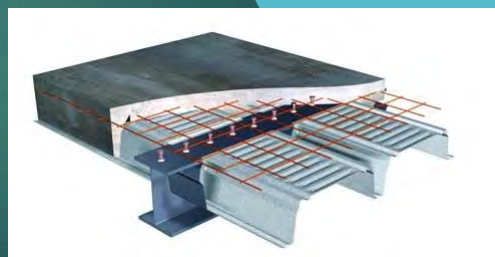
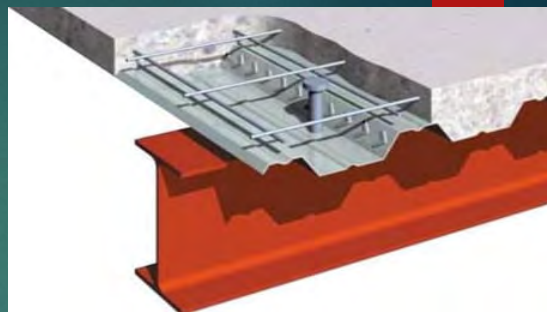
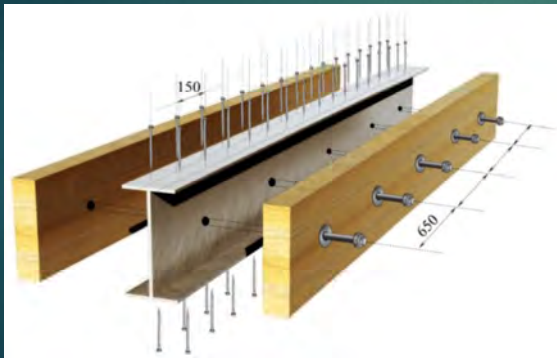
130

# Framing Systems



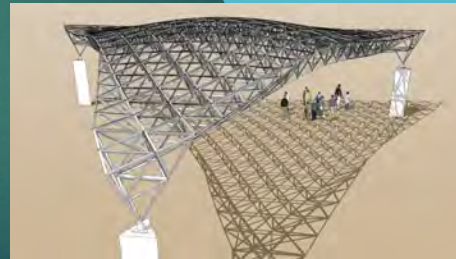
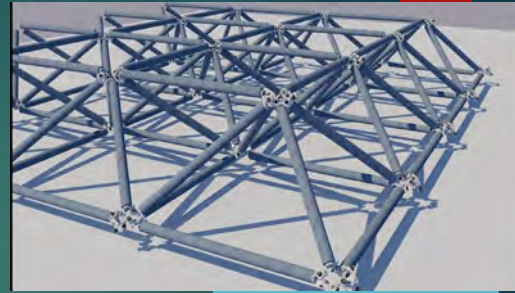
131

# Composite Systems



132

## Space Frames



133

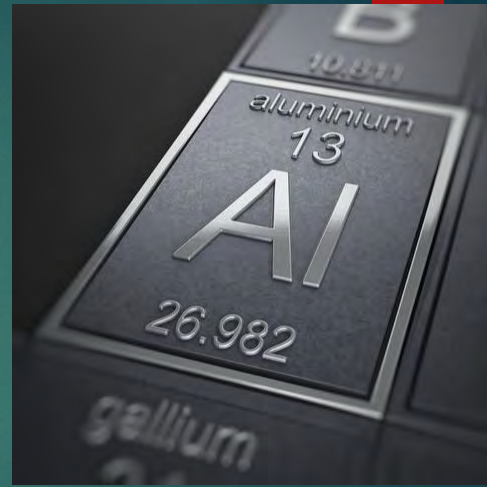
## Cor-ten steel weathering steel

- ▶ 1933 US Steel
- ▶ Developed for rail cars
- ▶ Corrosion resistance
- ▶ Mayari-R weathering steel (Bethlehem Steel)
- ▶ Structural shapes/Plate/Industrial applications
- ▶ Problems with high humidity/ponding
- ▶ Connection issues
- ▶ Staining issues



134

# Aluminum



135

# Properties

Aluminum alloys are divided into the wrought and cast categories according to how they are produced.

- ▶ The wrought category includes rolling, extruding, drawing, forging, and a number of other more specialized processes.
- ▶ Cast alloys are poured molten into sand (sand casting) or high-strength steel (permanent mold or die casting) molds where they solidifies to produce the desired shape.
- ▶ Weight 170 pcf
- ▶ Melting point – 1,221°F



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## Uses

- ▶ Architectural Metals
- ▶ Doors & windows
- ▶ Curtin wall systems
- ▶ Electrical & Wiring
- ▶ Beams
- ▶ Rack systems



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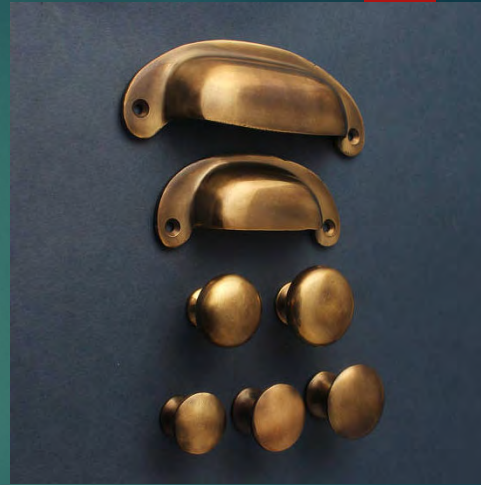
## Brass



138

## Properties

- ▶ Alloy of copper and zinc
- ▶ not ferromagnetic
- ▶ Corrosion resistant
- ▶ Relatively Soft
- ▶ Melting point 1,650 – 1,720 °F



139

## Uses

- ▶ Architectural metals
- ▶ Electrical
- ▶ Plumbing



140

# Copper



141

# Properties

- ▶ Corrosion resistant
- ▶ Ductile
- ▶ Excellent electrical conductivity
- ▶ Melting point – 1,981°F



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## Uses

- ▶ Roofing
- ▶ Plumbing
- ▶ Wiring/electrical
- ▶ architectural



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## Glass



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## Annealed Glass

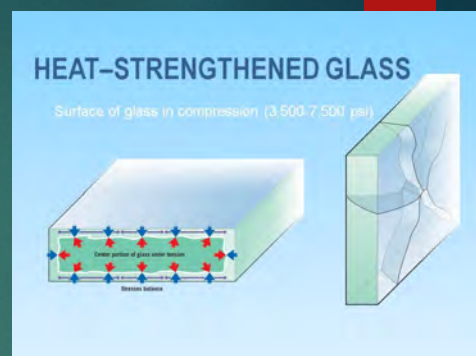
Annealed glass means that it has been slowly cooled, helping the glass to be stronger, more durable and less likely to break. When the glass is broken, it breaks into large shards of glass



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## Heat Strengthened

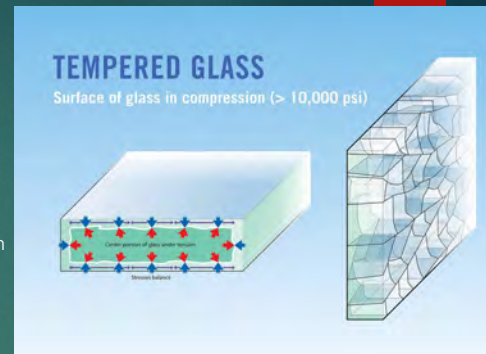
- ▶ Heating the glass to approximately 1,200 degrees Fahrenheit, then force-cooling it to create surface and edge compression
- ▶ In the end, heat-strengthened glass is approximately twice as strong as annealed, or untreated, glass.
- ▶ specified when additional strength is needed to resist wind pressure, thermal stress or both



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## Tempered Glass

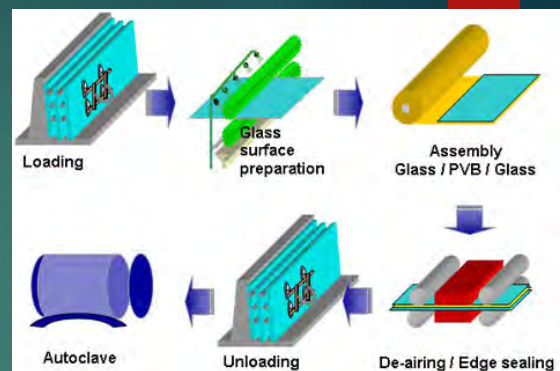
- ▶ Heating the glass to approximately 1,200 degrees Fahrenheit, then force-cooling it to create surface and edge compression
- ▶ the cooling process is accelerated to create higher surface compression and/or edge compression in the glass.
- ▶ the glass is four to five times stronger and safer than annealed or untreated glass.
- ▶ fractures into relatively small pieces, thereby greatly reducing the likelihood of serious cutting or piercing injuries in comparison to ordinary annealed glass.
- ▶ Once the glass has been tempered, it can no longer be altered.



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## Laminated Glass

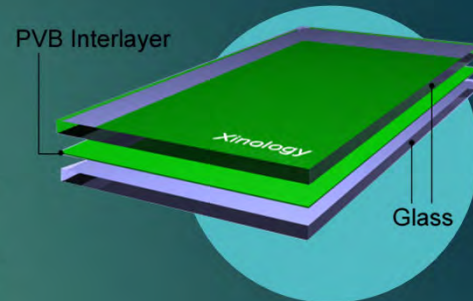
- ▶ Laminated glass is basically a glass sandwich. It is made of two or more plies of glass with a vinyl interlayer between. The glass will tend to stay together and case one in is broken – thus qualifying as a safety glazing material.
- ▶ Laminated glass can be made from annealed glass, from tempered glass, or from combinations of the two.



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## Poly Vinyl Butyral (PVB) Glass

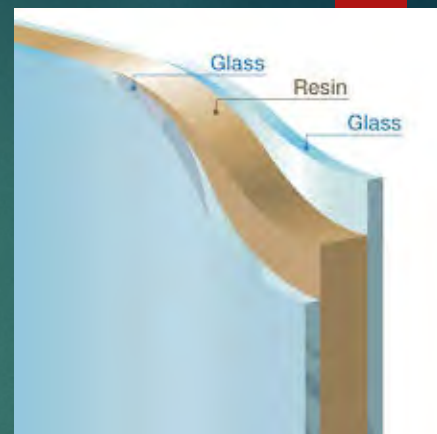
- ▶ Laminated glass, commonly used in the automotive and architectural fields, comprises a protective interlayer, usually polyvinyl butyral, bonded between two panels of glass. The bonding process takes place under heat and pressure. When laminated under these conditions, the PVB interlayer becomes optically clear and binds the two panes of glass together. Once sealed together, the glass "sandwich" (i.e., laminate) behaves as a single unit and looks like normal glass. The polymer interlayer of PVB is tough and ductile, so brittle cracks will not pass from one side of the laminate to the other.
- ▶ PVB has gained acceptance among manufacturers of photovoltaic thin film solar modules.



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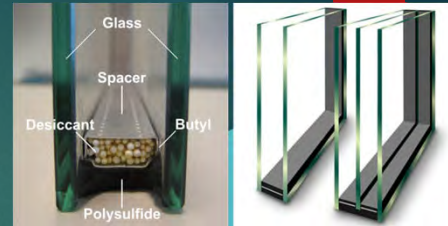
## Resin Laminated Cast-in-Place Glass

- ▶ The layer of resin is poured between the glass and ensures a superior safety aspect. In addition, resin layers offers interesting opportunities for sound insulation and design. The application of the resin intermediate layer is as follows. The two sheets of glass are held by a double-sided adhesive tape at a certain distance, after which the resulting cavity is filled up with resin. After the curing the laminated glass with resin practically has the same properties as a laminated glass with foil.



150

## Insulated Glass



- ▶ Insulated Glass Units (IGUs) feature two panes of glass separated by an inert gas
- ▶ The layer of gas diffuses heat transfer, which makes the window more energy efficient
- ▶ Insulated glass is often referred to as a unit since IGUs are also known as "double glazing" or "double-pane" glass windows
- ▶ can also contain up to three panes of glass where extra heat or sound insulation is required. Thicker glass is more expensive but more efficient.
- ▶ Gas – The gas used between the glass panes varies with each manufacturer. In general, an inert gas such as argon, krypton or a mixture of both creates the insulating barrier between the indoors and outdoors.



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## Low-Iron/Extra Clear Glass

- ▶ also known as extra-clear glass or optically clear glass, by reducing the amount of iron in the molten glass formula. This type is more transparent than regular glass, and doesn't have that greenish tint.
- ▶ When used in interior walls, low-iron glass also increases the flow of natural light. According to architecture and interior design trade magazine Architectural Record: "Due to its composition, low-iron glass can transmit up to 91 percent of light compared to the 83 percent associated with conventional clear glass, allowing it to be used in a variety of different applications."



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## Coated Glass

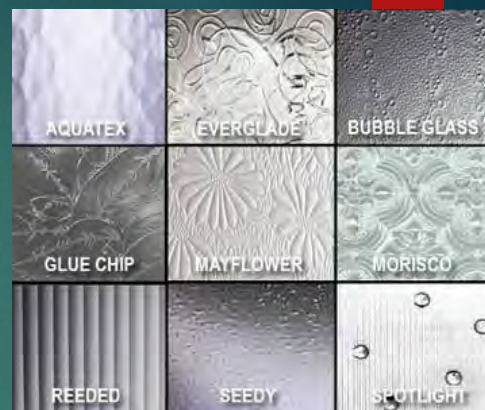
- ▶ *Coated glass is an industrial glass product onto which metal oxides are sprayed in the form of thin coatings (0.01  $\mu\text{m}$  to 0.8  $\mu\text{m}$ ). The coating is thus composed of a stack of sub-coatings of different types and thicknesses. It modifies the behavior of the glass with respect to solar radiation, in the visible and infrared domains. One distinguishes between pyrolytic and magnetron coatings. The latter can only be used on the internal surface of insulating glazing.*



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## Decorative Glass

- ▶ Glass that is used for more than just a functional purpose
- ▶ The use of decorative glass can range from doors (especially shower doors) to stairways and hand rails, desks, tables and walls. Furniture made of glass is classified as decorative glass, as are shelves and floors made of glass.



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## Acid Etched Glass

- ▶ Acid-etched glass refers to annealed glass that has been treated with hydrofluoric acid to give its surface a frosted look. Entire sheets of glass can be acid-etched or small sections can be treated to add specific designs.
- ▶ Acid-etching is seen as a great alternative to sandblasting because the finished surface is smoother to the touch and easier to maintain. The glass can also better withstand stress and stay smudge-free longer. Because of its durability, acid-etched glass can be cut into any shape or size and then tempered.



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## Fire Glass

- ▶ Fire-rated glass is specially designed to prevent the spread of flames and smoke, and depending on product makeup, the transfer of radiant and conductive heat.
- ▶ Glass Ceramic
- ▶ Wire Glass



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**Window / Door Test**  
**FIRE PROTECTIVE**  
 NFPA 257/252

**Wall Test**  
**FIRE RESISTIVE**  
 ASTM E119/NFPA 251

Contains flame and smoke  
**45 minutes and under**


Contains flame and smoke AND  
 blocks radiant heat for applications  
**over 45 minutes**



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# Plastics

- ▶ Fiberglass
- ▶ Polyvinyl Chloride (PVC)
- ▶ Acrylonitrile Butadiene Styrene (ABS)
- ▶ Chlorinated Polyvinyl Chloride (CPVC)
- ▶ Cross-linked Polyethylene (PEX)
- ▶ Polystyrene
- ▶ Polyisocyanurate



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# Gypsum



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# Calcination

- ▶ Calcination is the practice of dehydrating gypsum into plaster or stucco through a batch or continuous process which includes heating the gypsum to evaporate the crystalline water.



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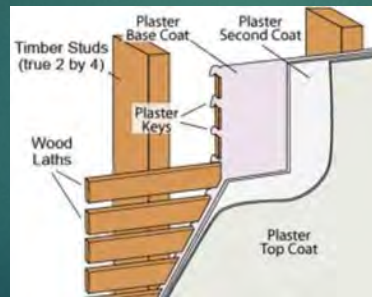


# Plaster



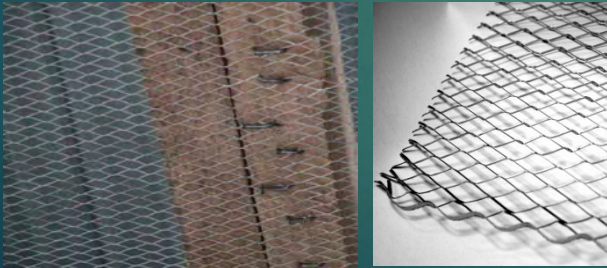
161

# Wood Lath



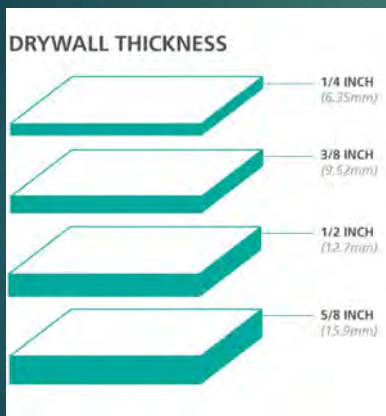
162

# Expanded Metal Lath



163

# Wall Board drywall



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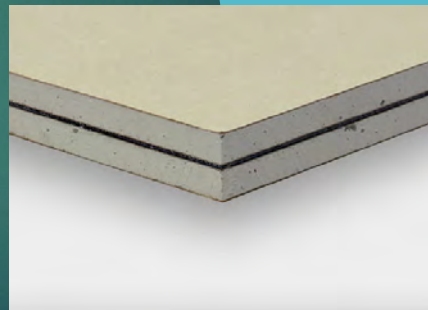
## Types

- ▶ Regular
- ▶ Predecorated
- ▶ Laminated
- ▶ Fire Resistant – Type X
- ▶ Impact Resistant
- ▶ Moisture Resistant
- ▶ Shaft Liner
- ▶ Gypsum sheathing
- ▶ Roof panels



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## Laminated



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# Fire Resistant/Type X Gypsum Board



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# Gypsum Sheathing



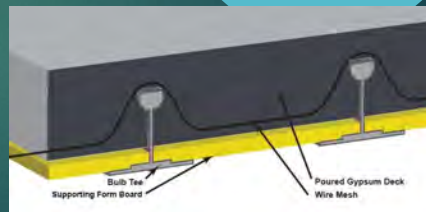
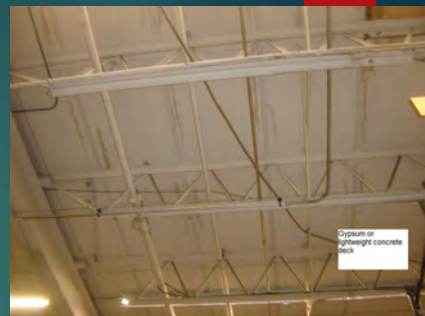
168

# Shaftliner



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# Roof Panels



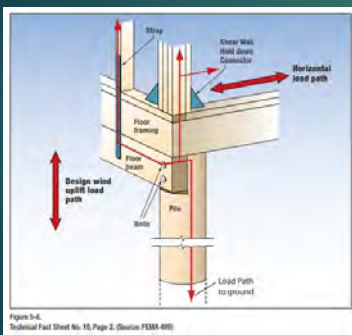
170

# Building Structural Elements



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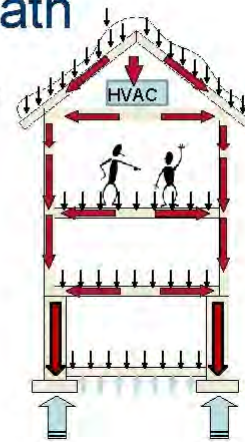
## Load Path

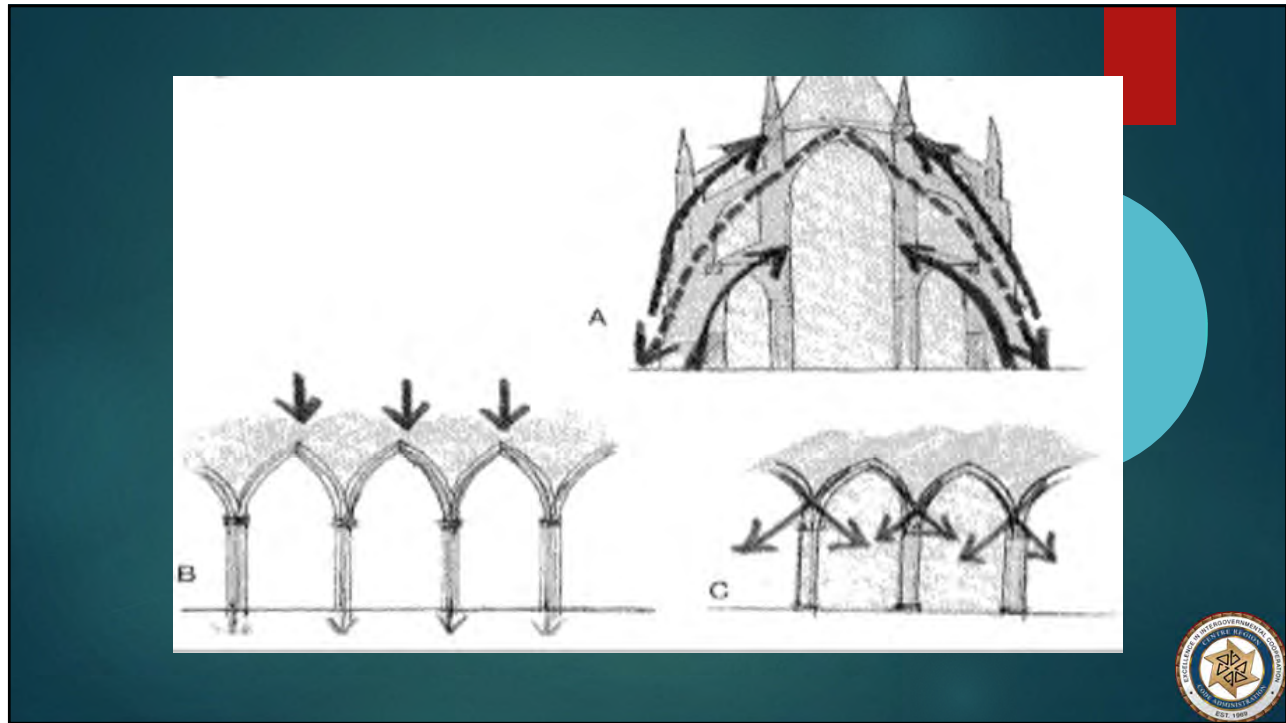


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## Load Path

- The path that a load travels through the structural system
- “Tracing” or “chasing” the loads
- Each structural element must be designed for all loads that pass through it

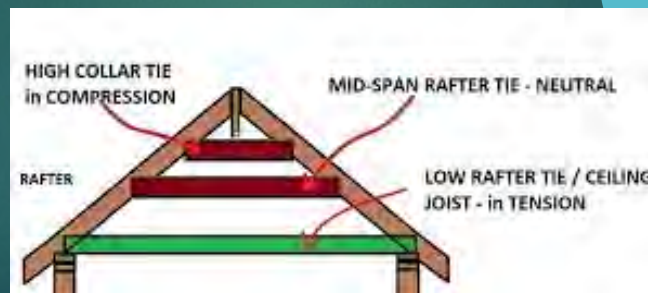




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## Ties

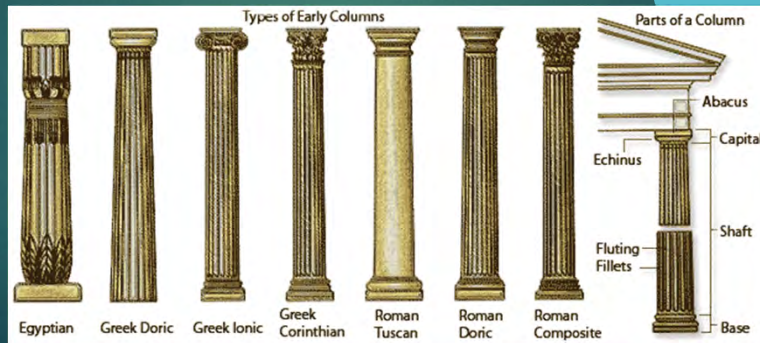
- ▶ Any unit of material which connects two parts
- ▶ A framing member which sustains only a tensile load



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## Columns/Posts/Studs

- ▶ A relatively long, slender structural compression member such as a post, pillar, or strut; usually vertical, supporting a load which acts in the direction of its longitudinal axis.



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## Beams/Lintels

- ▶ A structural member whose prime function is to carry transverse loads as a joist, girder, rafter, or purlin.

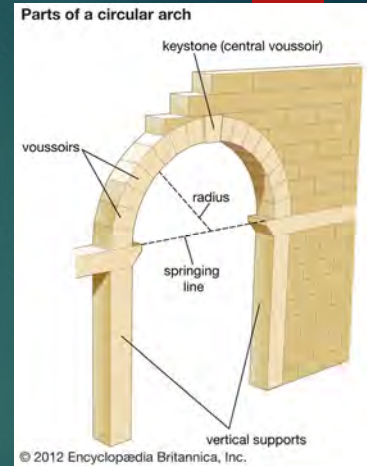


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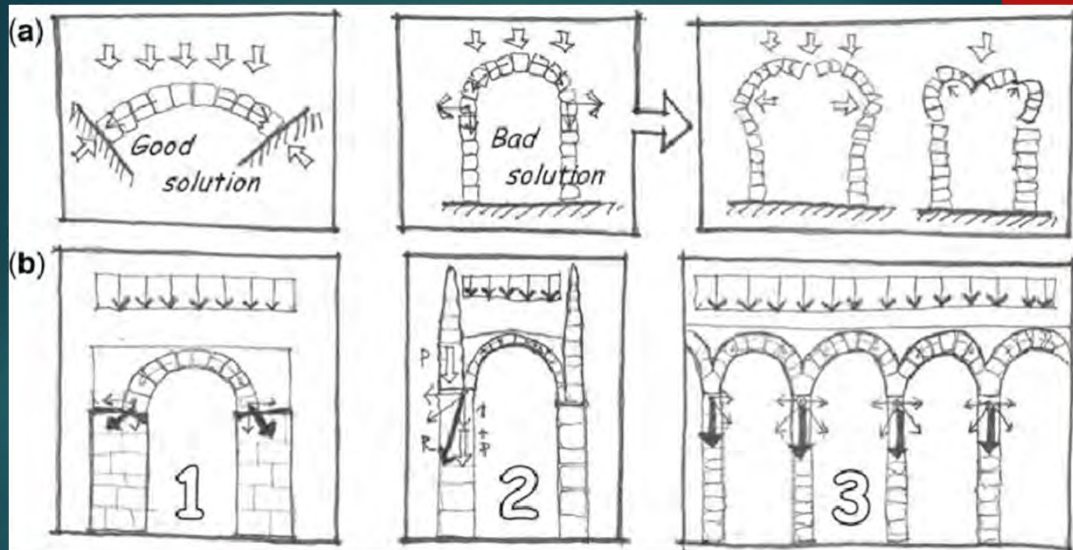


# Arches

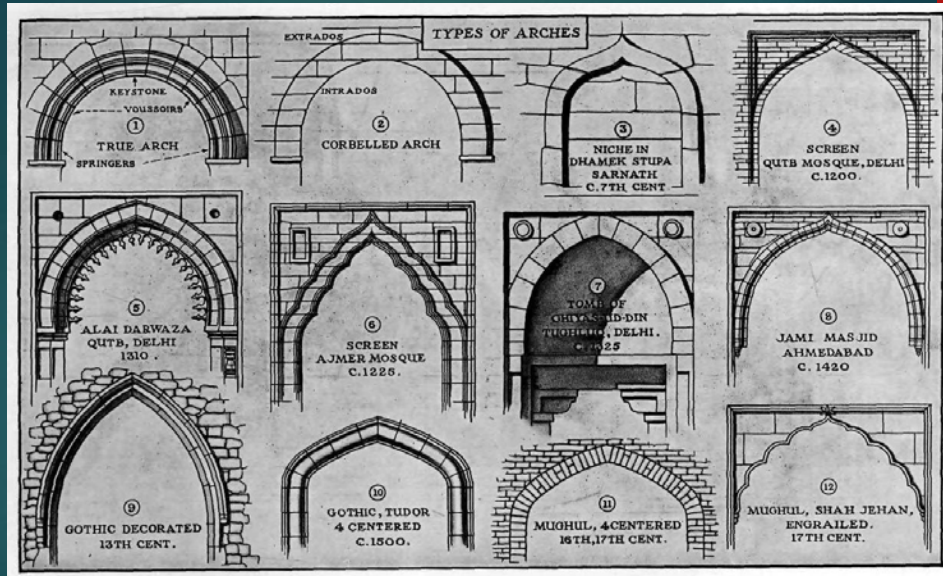
- ▶ A construction that spans an opening; usually curved; often consists of wedge shaped blocks having their narrower ends toward the opening.



177



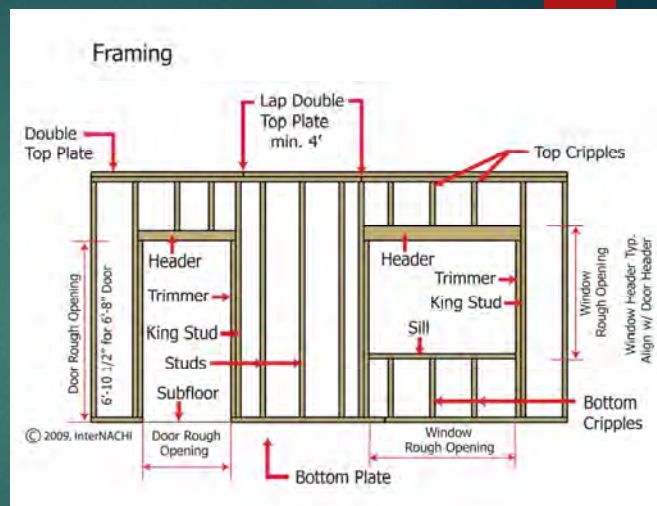
178



179

## Plates

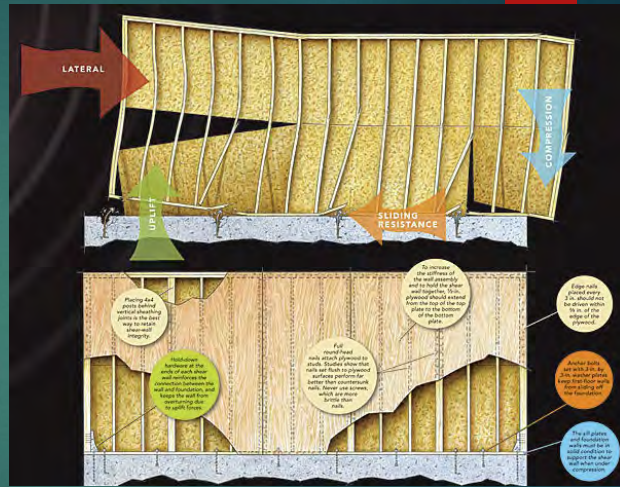
- ▶ A horizontal member connecting and terminating post, joists, rafters, etc.



180

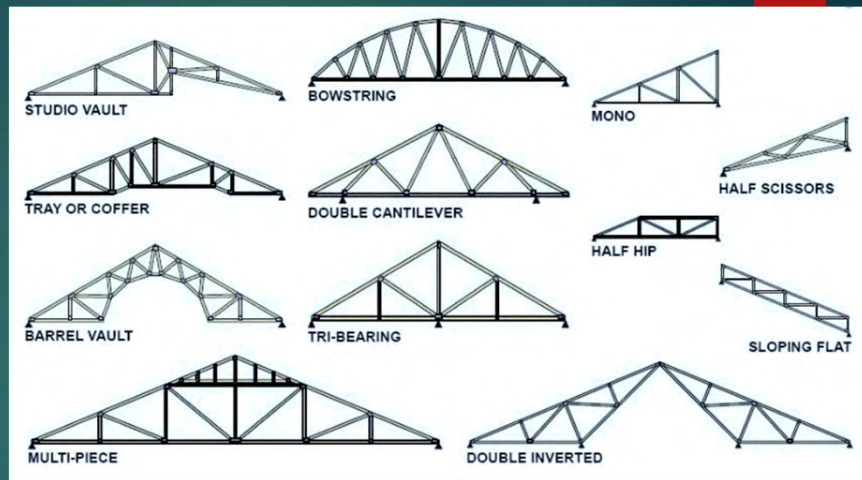
# Diaphragms Shear Walls

- ▶ A floor slab, wall panel, roof panel, or the like having a sufficient strength and stiffness to transmit horizontal forces to resisting systems
- ▶ A wall which in its own plane carries shear resulting from racking forces such as wind, blast, or earthquake



181

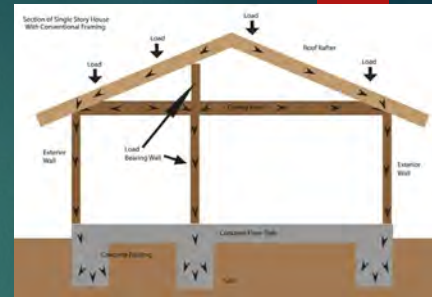
# Trusses



182

## Walls

- ▶ Load Bearing
- ▶ Partition
- ▶ Curtin



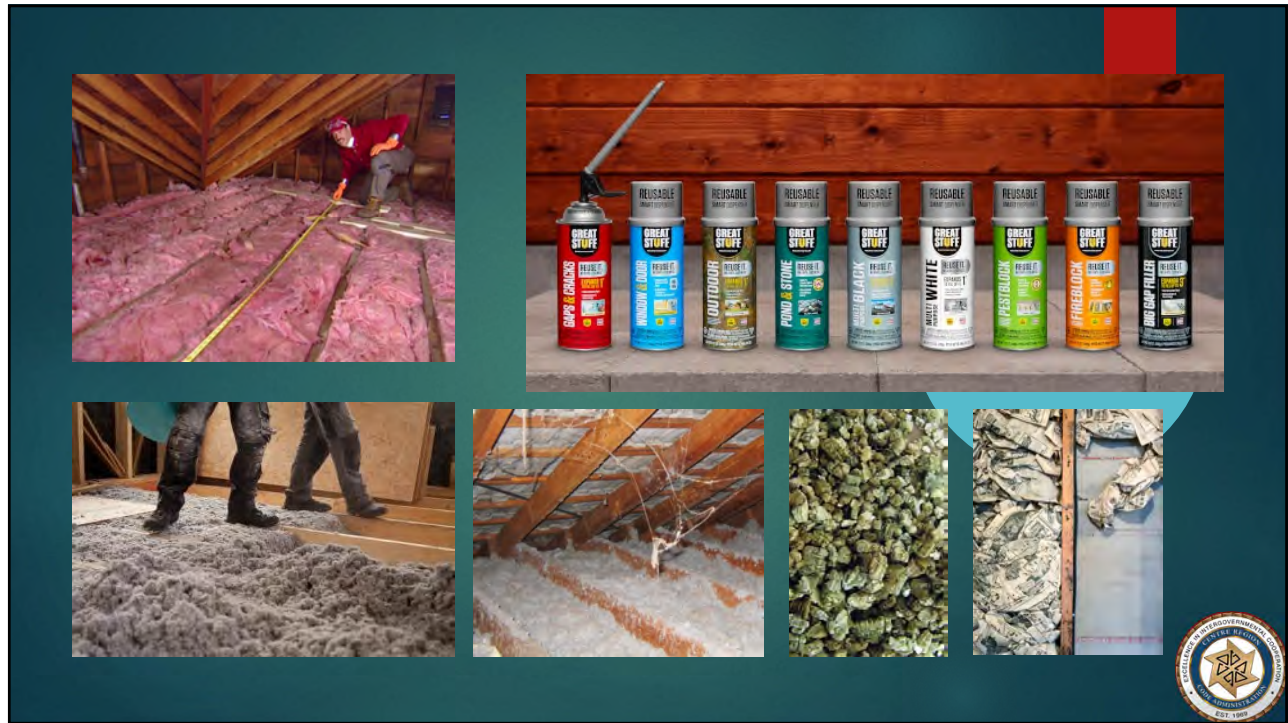
183

## Insulation

- ▶ Mineral Fiber
- ▶ Expanded Polystyrene
- ▶ Polyisocyanurate
- ▶ Polyurethane
- ▶ Fiberglass
- ▶ Newspaper
- ▶ Cellulose
- ▶ Asbestos
- ▶ vermiculite



184



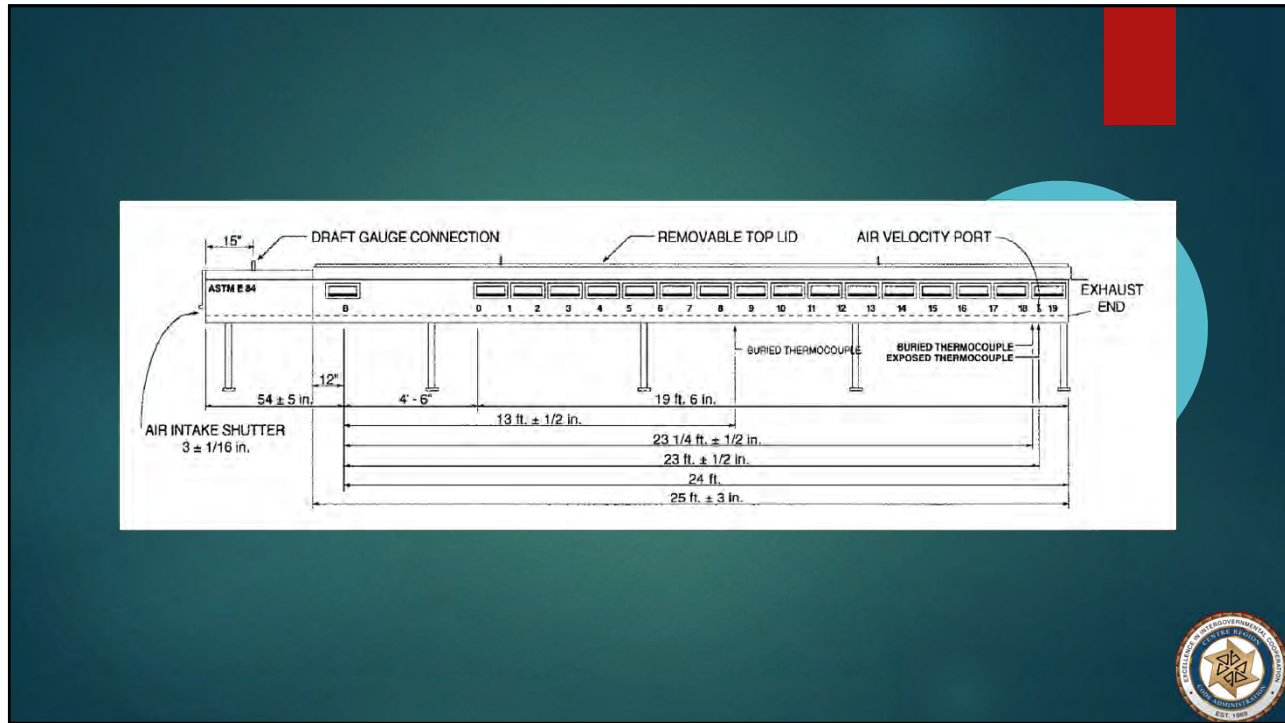
185

# Flame Spread Index

- ▶ ASTM E84/UL243 Standard Test Method for Surface Burning Characteristics of Building Materials
- ▶ Steiner Tunnel Test

	Flame-Spread Index (FSI)	Smoke Development Index (SDI)
Class 1 or Class A	0-25	450 Maximum
Class 2 or Class B	26-75	450 Maximum
Class 3 or Class C	76-200	450 Maximum

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Material/species	FlameSpread Rating	Flame-Spread Class
Hardboard siding panels	<200	III
APA Wood Structural Panels (Includes APA 303 Sidings such as T1-11)	76-200	III
Birch, Yellow	80	III
Brick	0	I
Cedar, Western Red	69	II
Douglas-fir	90	III
Fiberboard, Medium Density	167	III
Gypsum Wallboard	10-15	I
Gypsum Sheathing	15-20	I
fiber-cement exterior materials	0	I
Hemlock, West Coast	73	II
Idaho white pine	82	III

188

## Taxpayer



189

## Compartmentalization

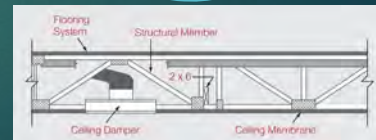
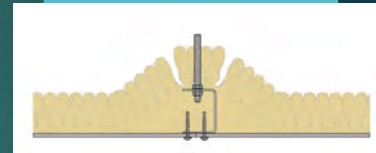
- ▶ practice of dividing large areas of a building into smaller rooms or spaces
- ▶ Slow/control the spread of fire



190

## Membrane protection

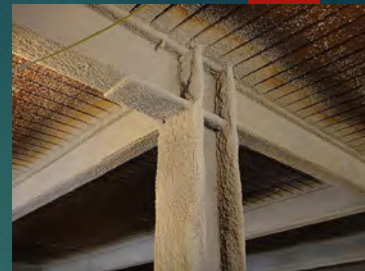
- ▶ Protect multiple members at the same time
- ▶ Ceiling/Floor Systems
- ▶ Wall Systems
- ▶ Details matter



191

## Encasement

- ▶ Concrete
- ▶ Masonry
- ▶ Drywall/Gypsum Board
- ▶ Flexible Blanket
- ▶ Sprayed fire-resistive materials
  - ▶ Issues
    - ▶ Bond Strength
    - ▶ Density
    - ▶ Thickness
  - ▶ Asbestos
  - ▶ Mineral-Fiber-Based
  - ▶ Cementitious



192



## Intumescent Coatings

- ▶ Epoxy-based paint like mixtures
- ▶ Expand when exposed to heat
- ▶ Thickness is critical



193

## Mobile v. Manufactured v. Industrialized

- ▶ Mobile homes are any manufactured home built prior to June 15, 1976. They are now obsolete due to HUD policy changes in 1976
- ▶ Manufactured homes are completely constructed in a factory and then transported to the home site under HUD regulations, also referred to single wide and double wide
- ▶ Industrialized homes are designed to be installed on a permanent foundation, built in a factory to the model building code and transported to the construction site



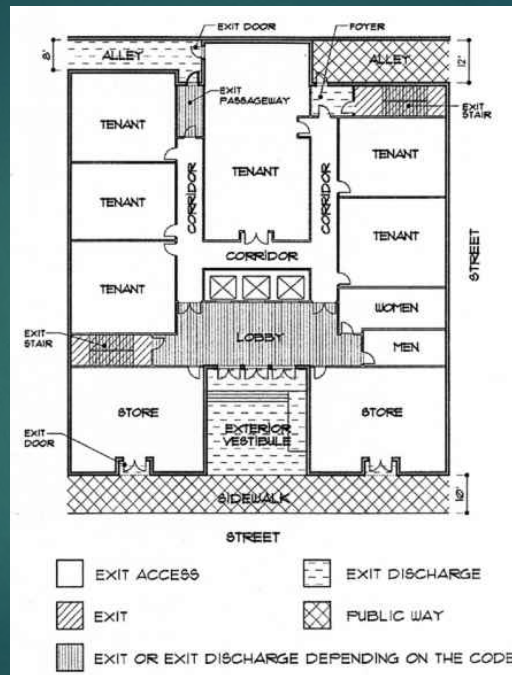
194

# Means of egress

- ▶ MEANS OF EGRESS. A continuous and unobstructed path of vertical and horizontal egress travel from any occupied portion of a building or structure to a public way. A means of egress consists of three separate and distinct parts: the exit access, the exit and the exit discharge.
- ▶ PUBLIC WAY. A street, alley or other parcel of land open to the outside air leading to a street, that has been deeded, dedicated or otherwise permanently appropriated to the public for public use and which has a clear width and height of not less than 10 feet.
- ▶ Exit Access
- ▶ Exit
- ▶ Exit Discharge

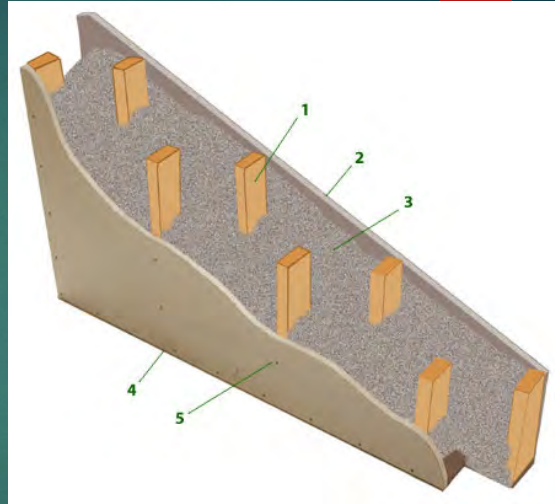


195



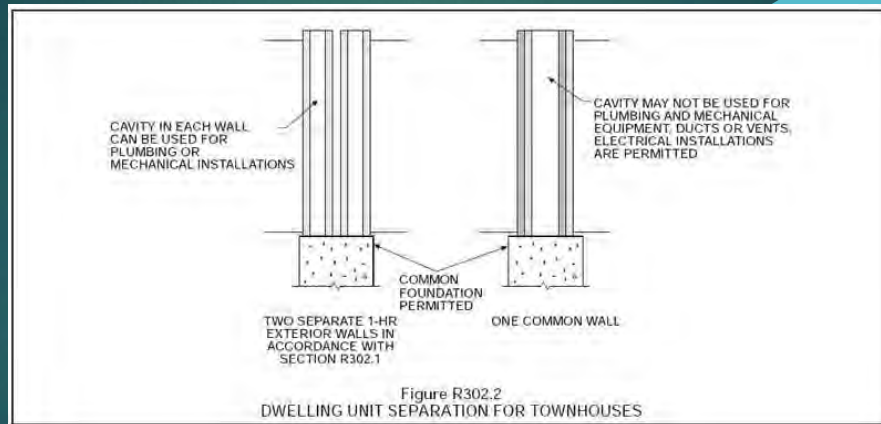
196

# acoustic wall



197

# Fire Walls



198

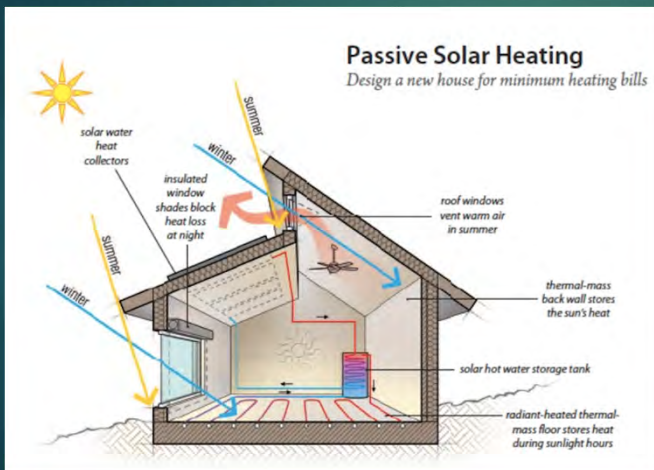
# Solar

- ▶ Passive Solar
- ▶ Hydronic
- ▶ Photovoltaic



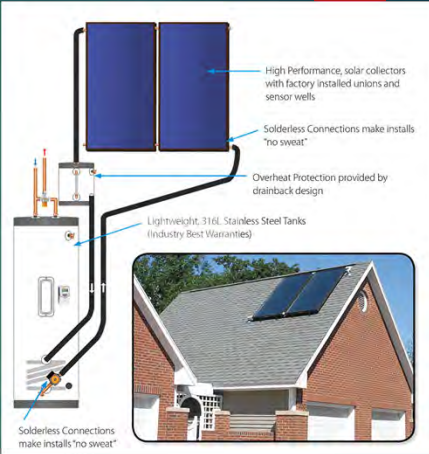
199

# Passive solar



200

# Hydronic

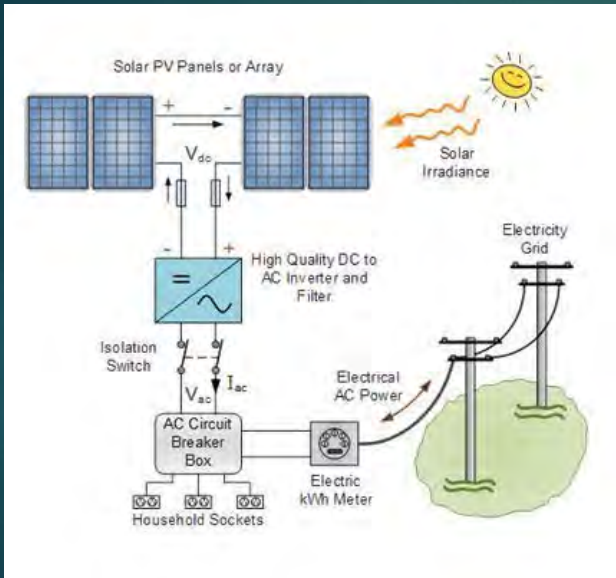


201

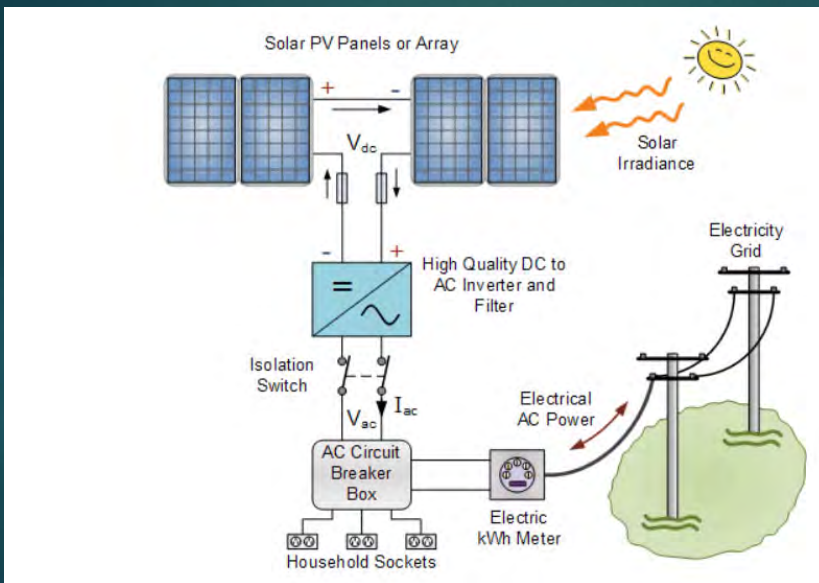
# Photovoltaic



202



203



204



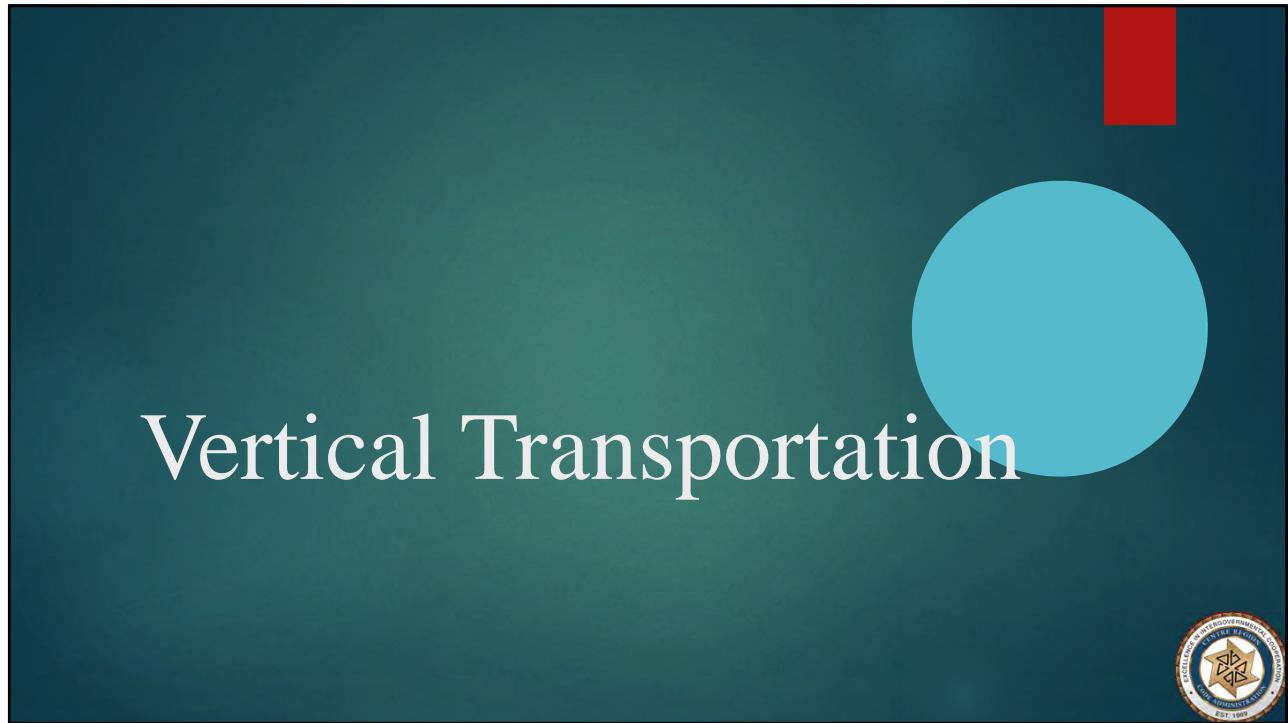
**Simplified Stand Alone PV System**

The diagram illustrates a simplified stand-alone PV system. At the top, 'Solar PV Panels or Array' are shown receiving 'Solar Irradiance' from the sun. The panels are connected to a 'Charge Controller' which regulates the flow of DC voltage ( $V_{dc}$ ) and current ( $I_{dc}$ ). The system includes a 'D.C. Load (Lighting)' connected to the positive DC line, and a '12 to 48 volt Battery Bank' connected to the positive DC line through 'Fuses'. An 'Inverter' is connected to the positive DC line, which converts the DC power into AC power ( $V_{ac}$ ) and current ( $I_{ac}$ ). The AC power is then used to power an 'A.C. Load (TV, Stereo)'. An 'Isolation Switch' is placed between the inverter and the AC load for safety. A photograph on the right shows a real-world implementation of a battery bank with several yellow and grey batteries mounted on a metal rack.

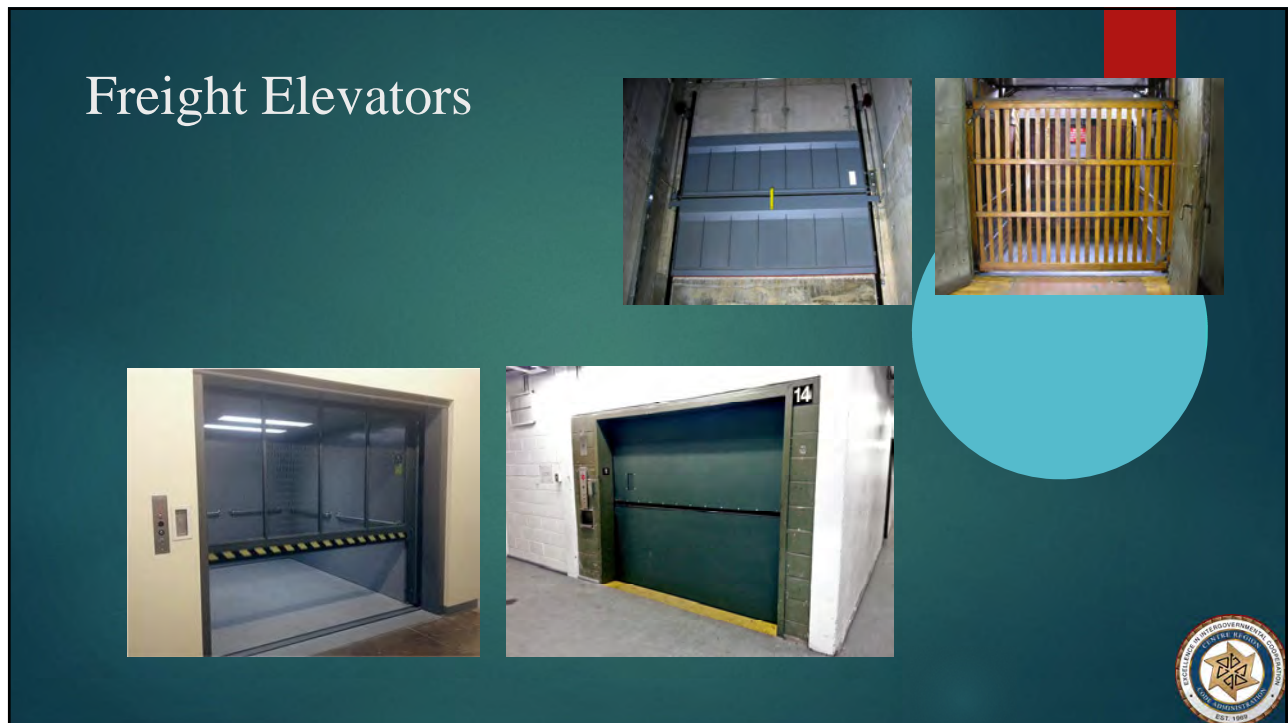
205

The photograph shows a wall-mounted electrical system. On the left is a grey electrical meter with a circular dial. To its right is a white, vertical inverter with a digital display and a power outlet at the bottom. Further right is a large, grey, rectangular solar panel with a textured surface. Wires connect the components to a vertical metal conduit on the wall.

206



207



208



# Passenger Elevators



209

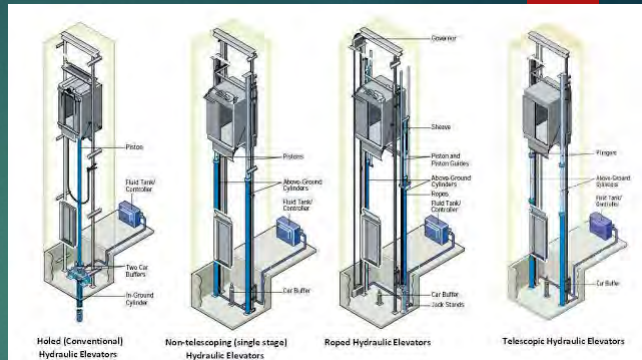
# Traction

- ▶ Type
  - ▶ Gear
  - ▶ Gear-less
- ▶ Machine Location
  - ▶ Top Mount
  - ▶ Bottom Mount



210

# Hydraulic



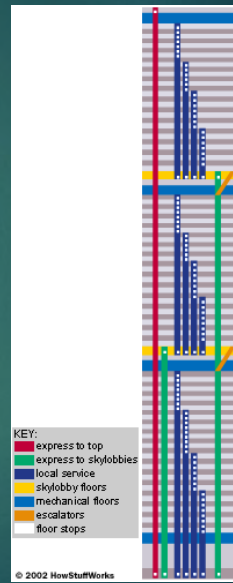
211

# Machine room less (MRL) elevator



212

# Hi-rise elevators



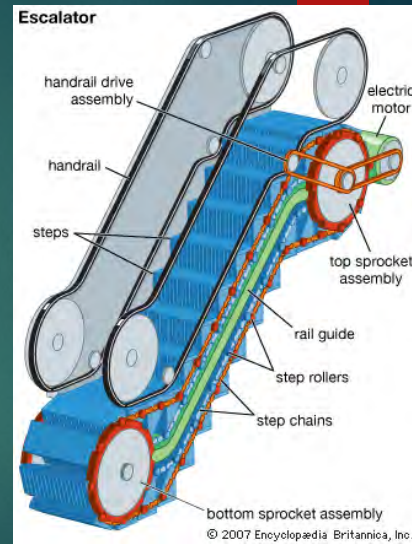
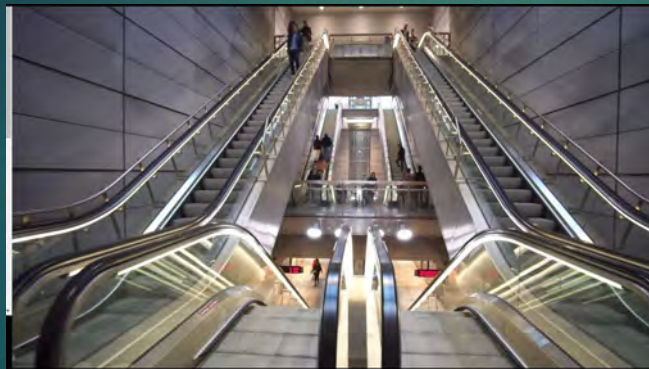
KEY:  
 express to top  
 express to skylobbies  
 local service  
 skylobby floors  
 mechanical floors  
 escalators  
 floor stops

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213

# Escalators



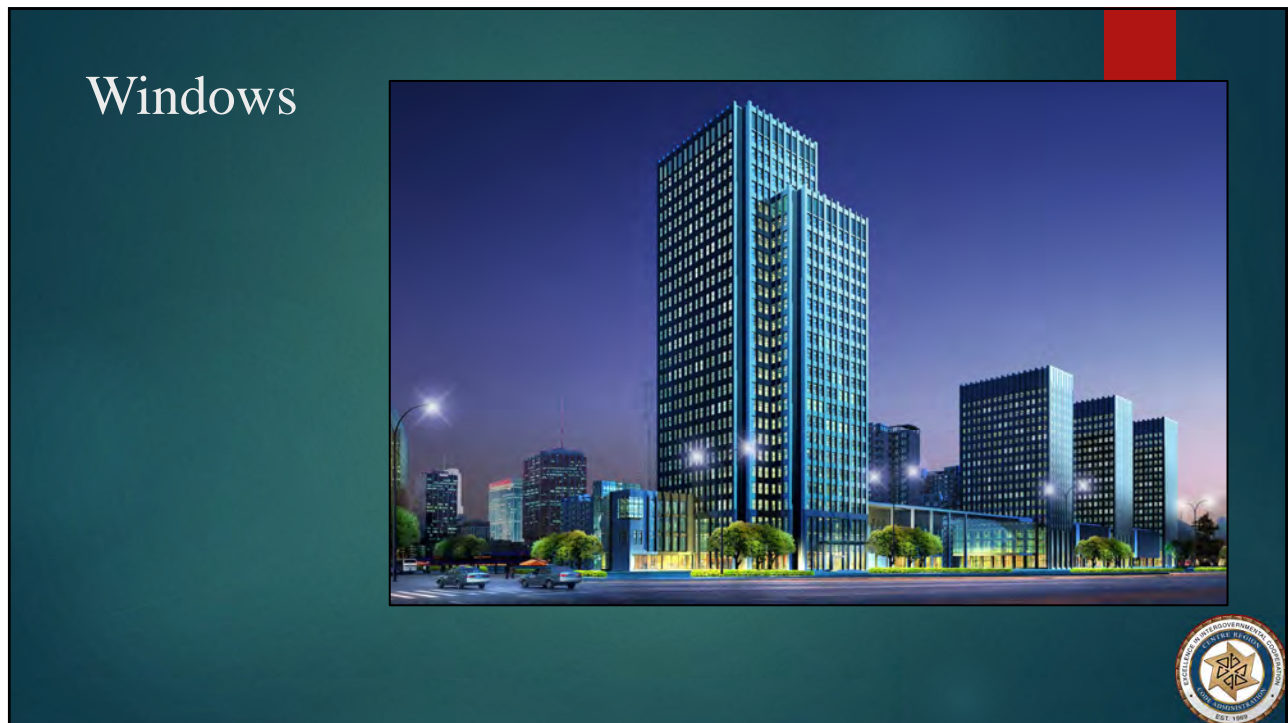
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214



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216

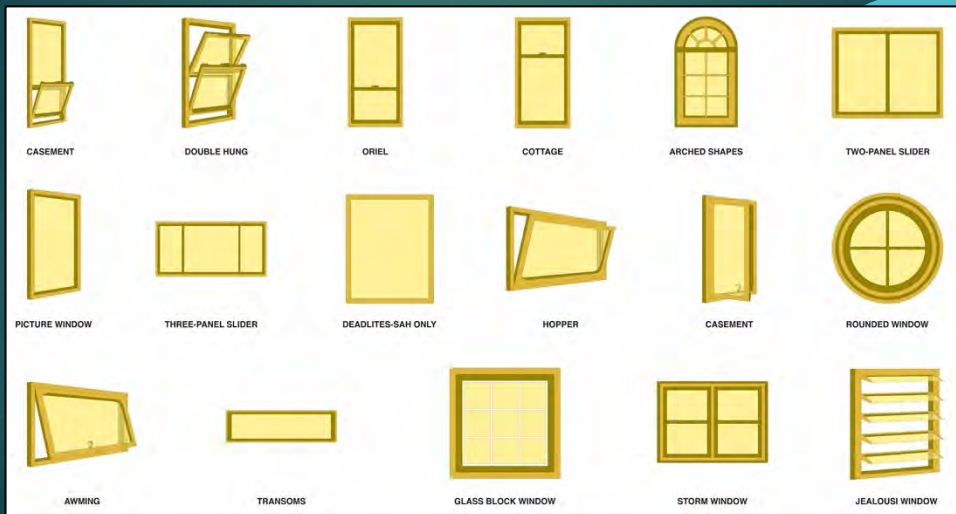
# Materials

- ▶ Wood
- ▶ Steel
- ▶ Aluminum
- ▶ Vinyl



217

# Operation



218

# Pivot horizontal & vertical



219

# Tilt and Turn



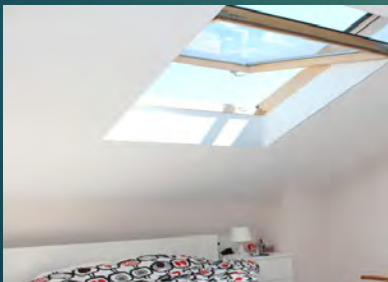
220

# Bi-Fold horizontal & Vertical



221

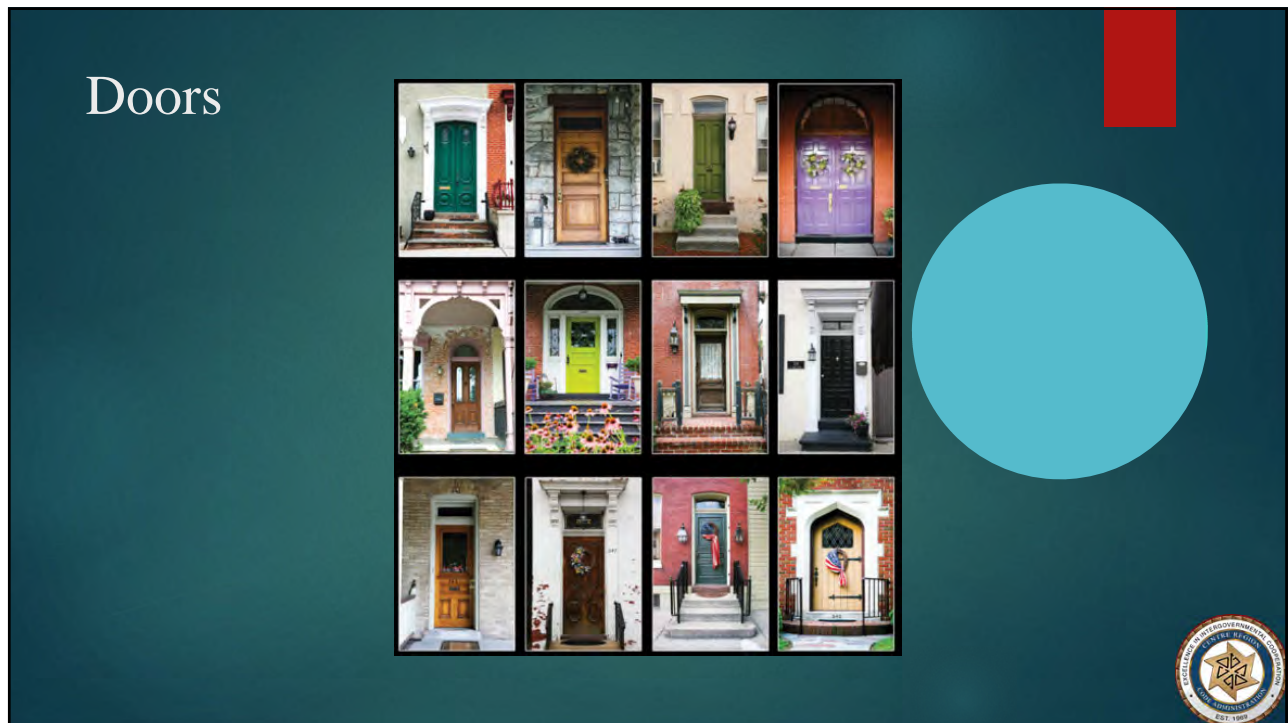
# Skylight



222



223



224



# Materials

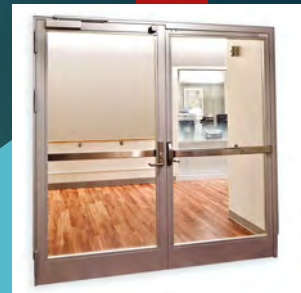
- ▶ Wood
- ▶ Glass
- ▶ Steel
- ▶ Pvc
- ▶ Fiberglass
- ▶ Aluminum
- ▶ Fiber Reinforced Plastic (FRP)



225

# Construction

- ▶ Battened & Ledged
- ▶ Glazed
- ▶ Panel
- ▶ Flush
  - ▶ Solid Core
  - ▶ Hollow Core
- ▶ Louvered
- ▶ Wire Gauzed



226


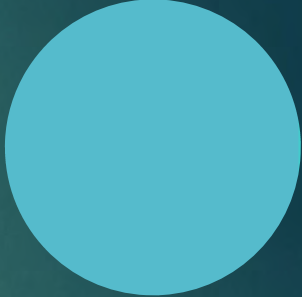
# Operation

- ▶ Swinging
- ▶ Sliding
  - ▶ Pocket
  - ▶ Bypass
- ▶ Rolling
- ▶ Revolving
- ▶ Collapsible
- ▶ Pivot



227

# Exterior cladding



228

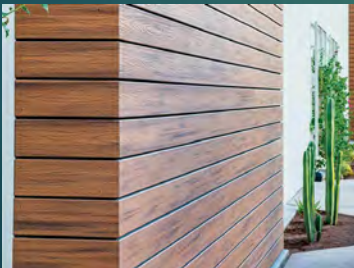
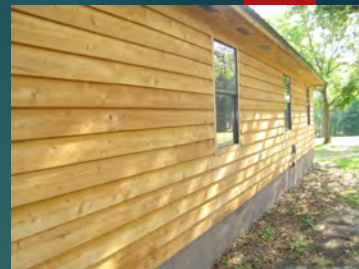
# Curtain Wall Systems

These walls are not structural, and by design, they are only able to carry their own weight, while transferring the load of wind and gravity to the structure of the building. The design makes it air and water resistant, to ensure that the interior of the building remains airtight.



229

# Wood



230

# Vinyl/plastic



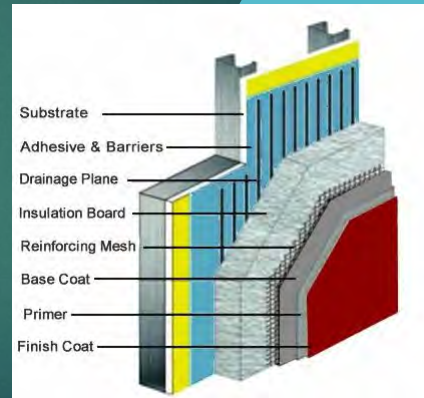
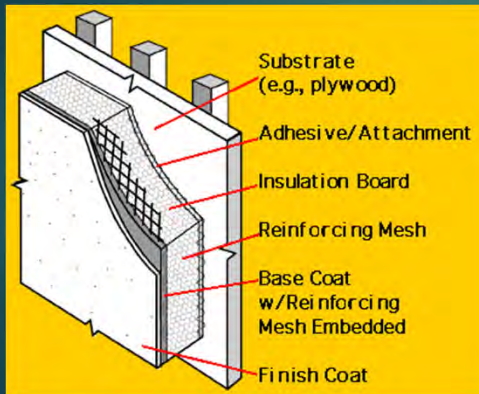
231

# Cement Board/Hardy Board



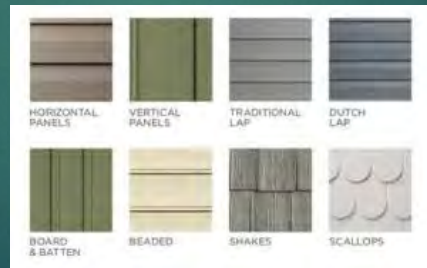
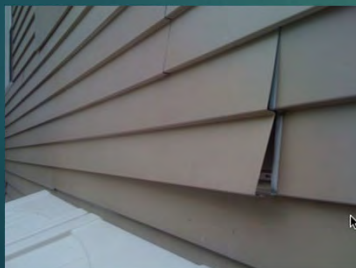
232

# Exterior Finish Insulation System (EFIS)/Dryvit



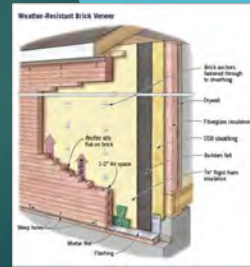
233

# Aluminum/steel

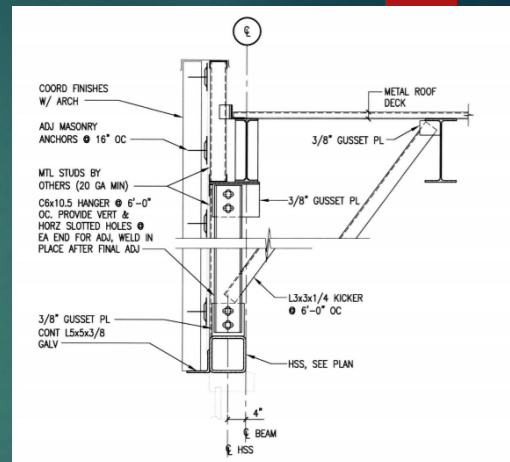


234

# MASONRY Veneer Stone/Brick



235



236

# Precast Concrete



237

# Glass



238

# Roof Types



239

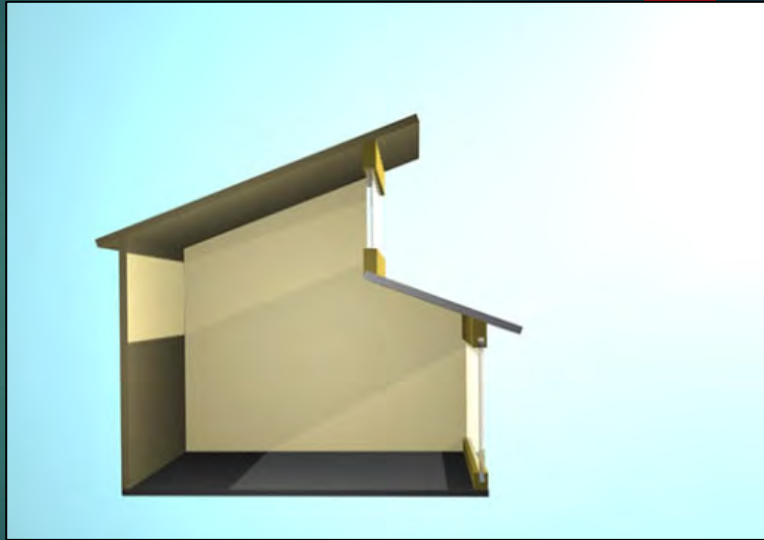
# Types



240



# Clear Story



241

# Roof Covering



Asphalt/Composition Shingle



Concrete Tile



242

# Roof Covering



Clay/Terracotta Tile



Wood Shakes/Shingles



243

# Roof covering



Metal Shingle



Standing Seam

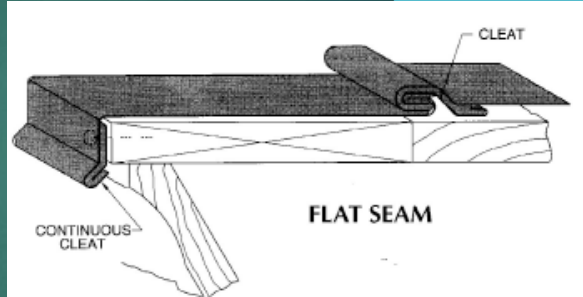


244

# Roof covering



Flat Seam



245

# Roof covering



Thermoplastic Polyolefin (TPO)



Modified Bitumen

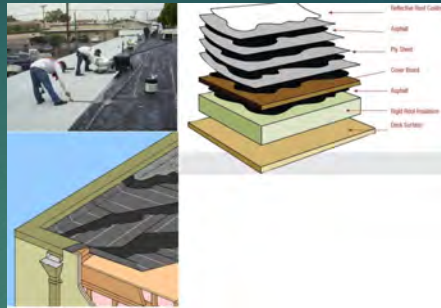


246

# Roof covering



Built-up Asphalt/Pitch



247

# Roof Covering



Ethylene Propylene Diene Monomer (EPDM)/Rubber

- ▶ Mechanically adhered
- ▶ Fully adhered
- ▶ Plate Adhered
- ▶ Ballasted



248

# Roof covering



Polycarbonate



Spray Polyurethane Foam



249

# Roof covering



Asbestos Shingles



Slate



250

# Roof covering



Rubber Slate

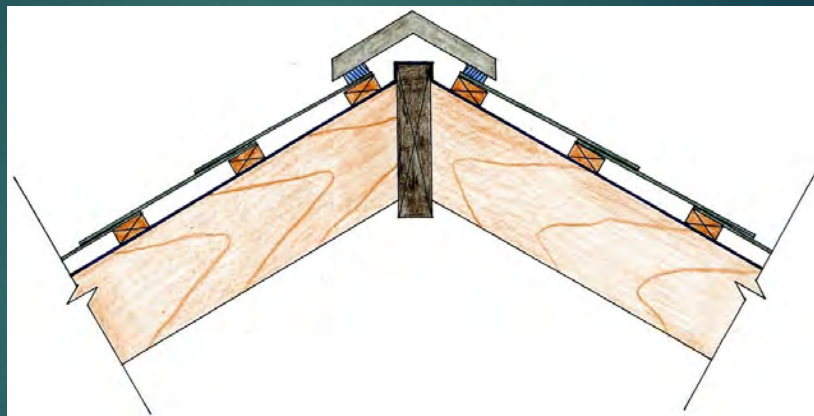


Plastic Polymer



251

# Ridge



252

# Valley



253

# Dormer



254

# Shed Dormer



255

# Cupola



256

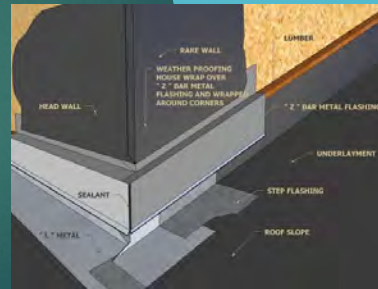


# Widows walk



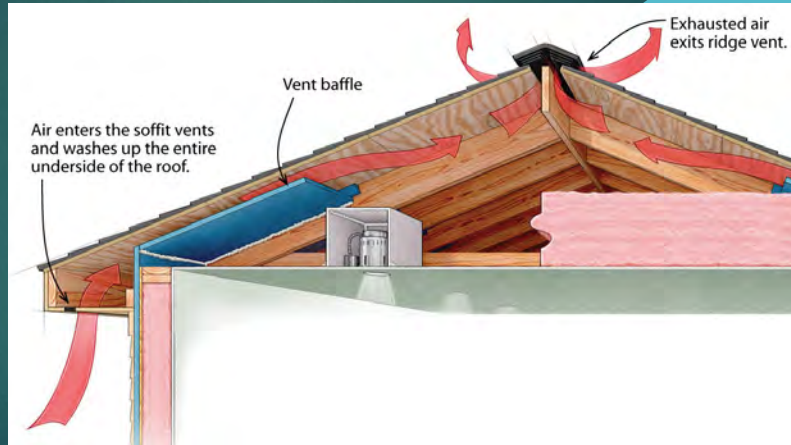
257

# Flashing



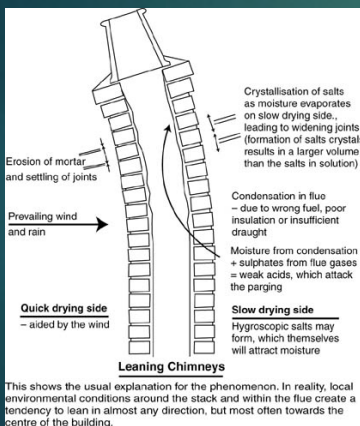
258

# Roof airflow



259

# Witches' bend



260

## What is an opening protective?

- ▶ FIRE DOOR - The door component of a fire door assembly.
- ▶ FIRE DOOR ASSEMBLY - Any combination of a fire door, frame, hardware and other accessories that together provide a specific degree of fire protection to the opening.



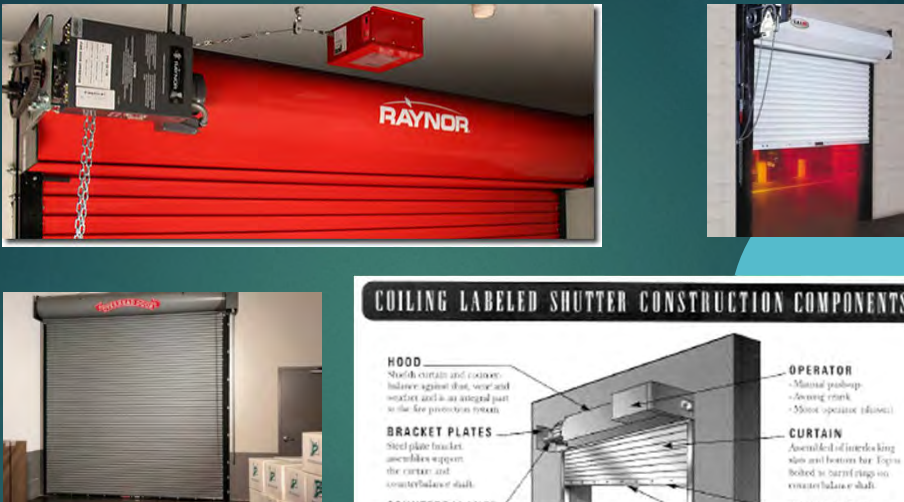
261

## What is an opening protective?

- ▶ FIRE WINDOW ASSEMBLY. A window constructed and glazed to give protection against the passage of fire.
- ▶ FLOOR FIRE DOOR ASSEMBLY. A combination of a fire door, a frame, hardware and other accessories installed in a horizontal plane, which together provide a specific degree of fire protection to a through-opening in a fire-resistance-rated floor (see Section 712.8).



262



### COILING LABELED SHUTTER CONSTRUCTION COMPONENTS

**HOOD**  
Wraps curtain and counterbalance against dust, wear and weather and is an integral part to the fire protection system.

**BRACKET PLATES**  
Steel plate bracket assemblies support the curtain and counterbalance shaft.

**COUNTERBALANCE**  
Steel shaft containing adjustable counterbalancing springs.


**GUIDES**  
Roll formed guide to assure smooth tracking operation of shutter.

**OPERATOR**  
- Manual pushup  
- Access mark  
- 55000 operator (optional)

**CURTAIN**  
Assembly of interlocking side and bottom bar. Ends bolted to barrel rings on counterbalance shaft.


**BOTTOM BAR**  
A reinforcing member at the bottom of the curtain.

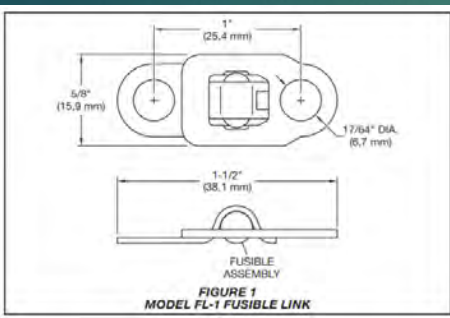
**SENSOR EDGE**  
Electrical or pneumatic device to stop or stop and reverse should the door open an obstacle when closing.




263

Temperature Rating	Maximum Allowable Temperature Exposure	Link Color	Part Number
165°F (74°C)	100°F (38°C)	None	56-125-9-165
212°F (100°C)	150°F (66°C)	White	56-125-9-212
286°F (141°C)	225°F (107°C)	Blue	56-125-9-286
360°F (162°C)	300°F (149°C)	Red	56-125-9-360
500°F (260°C)	475°F (246°C)	Orange	56-125-9-500





**FIGURE 1  
MODEL FL-1 FUSIBLE LINK**



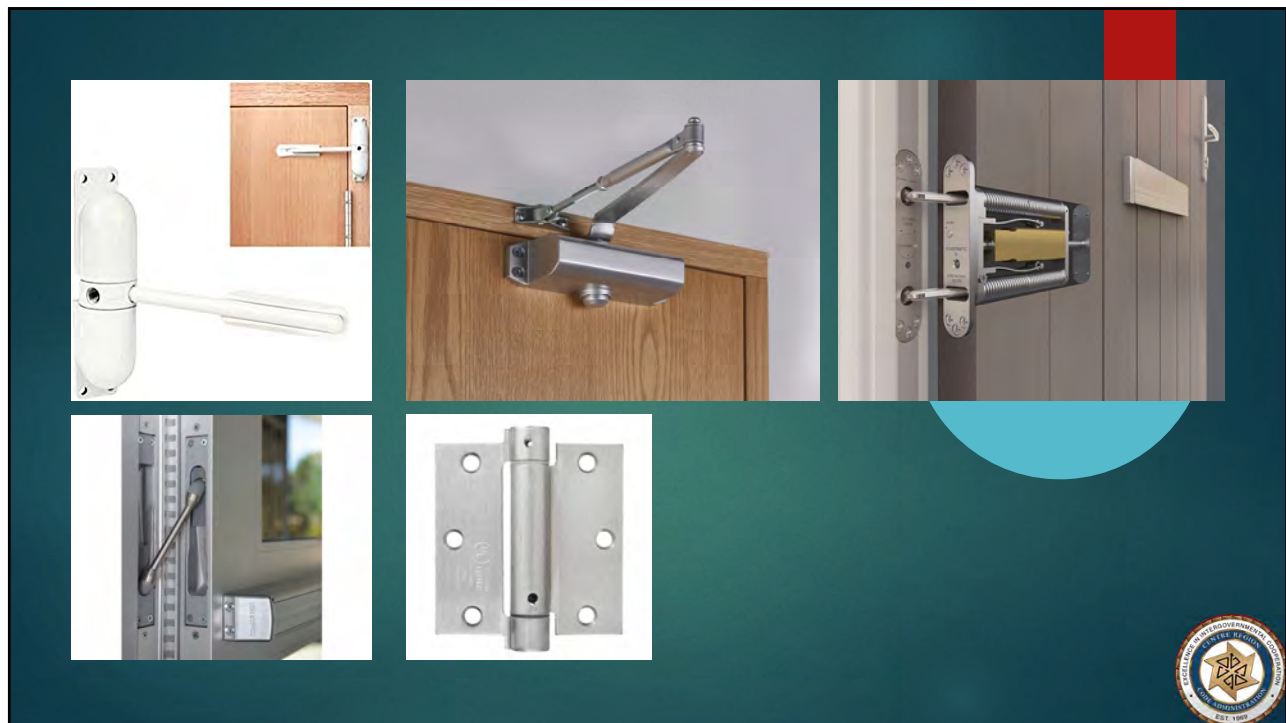
264

# Heat transfer

- ▶ CONDUCTION: The transfer of heat from the direct contact of a solid of higher temperature to a solid of lower temperature
- ▶ CONVECTION: The transfer of heat through the movement of hot smoke and gases to solid surfaces of lower temperature
- ▶ RADIATION: The transmission of heat energy by electromagnetic waves through the space between a body at a higher temperature to a body at a lower temperature



265



266

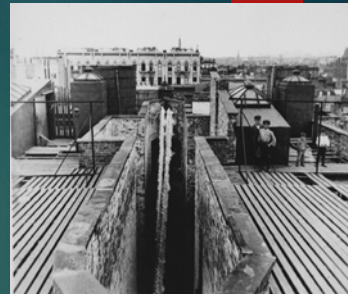
## Cockloft vs. Attic

- ▶ Depends on your school of thought...
- ▶ The cockloft is a combustible void space between the top floor ceiling and the roof.
- ▶ Typically attics are spaces that can be occupied for storage or other activities.
- ▶ Some people state that cocklofts have sloped roofs and attics have pitched roofs.
- ▶ Either way they are a large void and potential for fire travel



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## Shafts



268



269